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THE REX—RED CLIFF DOUBLE TRACK CONSTRUCTION ON THE DENVER AND RIO GRANDE R. R.

The Denver & Rio Grande R. R. makes its crossing of the continental divide between Pueblo and Grand Junction, Colorado, in a distance of 331 miles. Starting westward from Pueblo, the ruling rising gradient is 1.42% to the summit at Tennessee Pass, 162 miles distant, where the mountains are pierced by a tunnel 2,572 ft. long at an elevation of 10,239 ft. above the sea. The western downward slope from the summit to Minturn, 21 miles in distance, has a ruling gradient of 3%; from Minturn to Glenwood, 58 miles, 1.33% and from Glenwood to Grand Junction, 90 miles, the controlling grade drops to 1.0%.

At Salida, 96 miles west of Pueblo, there is a division terminal where are effected complete changes of locomotives, engine crews and train crews in both freight and passenger service. Thus the portion of the main line between Salida and Minturn is an engine district for both freight and passenger service. In addition the short stretch of 3% grades between Minturn and Tennessee Pass necessitates the use of a large number of helper engines. The home of these helpers is at Minturn, to which point they return light after a trip to Tennessee Pass. This condition tends towards a congestion of traffic on the 21 miles of 3% grades, and on account of the rapid growth of both freight and passenger business. It has been found imperative to construct a second main track over a portion of the distance. To facilitate the rapid dispatch of trains entering and leaving freight terminals the policy adopted some years ago was to construct double track for a short distance on either side and through the yards of such terminals. Hence in considering the matter of double tracking a portion of the 3% gradient it was deemed expedient to extend the second track eastward from Rex, the easterly end of the existing double track, through the Minturn terminals to Red Cliff, a distance of five miles. The country through which this five-mile section extends is so rough and difficult that the work of double tracking represents a labor not at all in keeping with the length of the line.

The section to be double-tracked follows the sinuous course of Eagle River as it cuts its way through a narrow and deep canyon. On account of the steepness of the banks of the canyon and the presence of a number of mining claims reaching quite to the water's edge, it was decided to place the new track, for the greater part of its length, on the opposite side of the river from the old line. In order not to exceed a curvature of 10° it became necessary to cross the river five times and to tunnel through points three times, all but one of which tunnels and bridges are on curves. The maximum gradient of the old track, 3% was reduced on the new line to 2.3%, a reduction of especial value since the new track is for eastbound or uphill trains. The above-mentioned mining claims necessitated the construction of many retaining walls to carry the track far enough away from the operations of the plant. One of these walls may be noted on Fig. 8.

FIG. 1. PORTAL OF TUNNEL IN EAGLE RIVER CANYON ON DENVER & RIO GRANDE R. R.

DETAILS OF CONSTRUCTION.—The grading and tunneling was carried on principally with air drills, the compressed air being furnished from a plant about midway of the line. The amounts of excavation and fill in the five miles are as follows:

Embankment	135,220	cu. yds.
Loose rock excavation	115,315	"
Solid rock excavation	153,705	"
Rip-rap	2,670	"
Retaining wall	6,190	"
Tunnel	760	lin. ft.

All bridges were of the plate-girder type, resting on concrete abutments and carrying the track on a ballasted system founded on a reinforced-concrete floor slabs. The five bridges comprise one double-track 48-ft. through girder, two single-track 80-ft. through girders and two single-track 80-ft. deck girders, one of the latter of which was on a tangent; all the rest were on curves. The details of these bridges are shown in Figs. 6-7. For the smaller drainage openings under the roadbed, cast-iron pipes and reinforced-concrete box culverts were used.

The tunnels were all driven through solid rock without timbering or other lining, and are notable because of the large section, viz: 18 ft. wide and 25 ft. high. This large section (Fig. 1) was adopted in order to conform closely to Denver & Rio Grande standard clearance diagram for steel bridges. Because so large a portion of the entire grading quantities consisted of rock excavation, the work was carried on through the winter months without serious inconvenience. Extreme vigilance in putting off blasts was necessary on account of the multitude of trains passing in such close proximity to the work, and the contractors are to be commended for the able manner in which the work of grading was conducted.

Denver & Rio Grande standard 85-lb. section rails 33 ft. long, with plain 4-bolt angle-bars and flat bottom tie-plates, were used in laying the track. In order to easily secure a proper and uniform amount of space at the variations in temperature the track was laid from Rex easterly or up-hill.

The entire work of construction was carried on without interruptions to traffic, and the new track was placed in operation for eastbound trains on October 27th, 1907.

The half-tones which are reproduced herewith impress one with the majesty of the country through which the line passes. Fig. 1 is taken at the portal of a tunnel (shown in Fig. 3) looking toward the small camp of Belden, some of the

houses of which may be seen at the top of the hill. Figs. 2, 7 and 8 are also taken in the vicinity of Belden, which in Figs. 7 and 8 is situated just at the top of the high cliff in the background.

We are indebted to the Engineering Department of the Denver & Rio Grande R. R. for the information and photographs herewith presented.

CEMENT MATERIALS ON THE ISTHMUS OF PANAMA.

The immense quantity of cement (estimated at 5,000,000 bbls.) to be used on the Panama Canal and the probability of high cost if it is transported from the States has led the government to institute an investigation into the cement material resources of the Isthmus with a view toward establishing there a government cement plant. The report of this investigation, which was carried on by Mr. Ernest Howe, Geologist of the U. S. Geological Survey, has recently been published in "The Canal Record."

A survey was first made of the surrounding country with the idea of locating limestone and clay of a composition which would form a good cement, but the material of this sort, similar to that ordinarily used in cement mills, was so limited in extent or so inaccessible that this line was abandoned. A search was then made for material of the correct chemical combination, even if not of the same physical formation as the usual cement ingredients. Happily this was found in abundance. For the base, or calcareous element, the coral reefs bordering the Caribbean coast in the vicinity of Colon, answer every purpose. This coral rock, a remarkably pure lime carbonate, is of very moderate hardness and may be easily obtained either by dredging or surface excavation. It may be crushed with little difficulty and would require no drying. For the siliceous or argillaceous element, two materials are available. The first is the clay and silt recently brought down the Chagres River and deposited near its mouth, or in the French Canal emptying into Limon Bay. These are of uniform composition and accessible so that they may be easily dredged. They are rather low in silica but contain a relatively large amount of iron as compared with alumina, and for this latter reason should be of value in forming a sea-water proof concrete; recent investigations have shown that the substitution of iron for alumina in cement removes one of the largest reagents in the deteriorating effects of the salts in sea-water. On account of the low silica content in the clays, a second argillaceous ingredient is proposed. This is a pumiceous rhyolite tuff, occurring at the western end of the Panama railroad bridge, near San Pablo, which is of approximately the same composition as the argillaceous materials used in the Lehigh district of Pennsylvania.

The disadvantage of the clay is the expense needed to dry it. It is thought possible, however, that a wet process of manufacture may be found, which in this instance would be more economical than drying the clay and employing the usual dry process. The objection to the tuff is its distance (about 20 miles) from the nearest point of landing the coral.

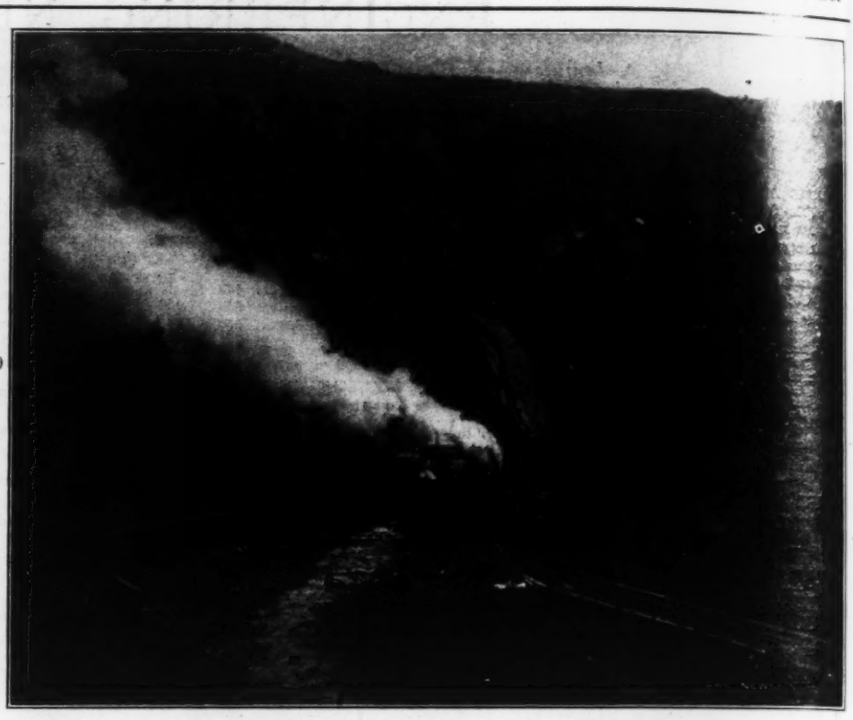

FIG. 2. DENVER & RIO GRANDE R. R. NEAR BELDEN, COL.

Samples of these three materials were sent to the Lehigh Valley Testing Laboratory at Allentown, Pa., and there crushed, burned and tested in three combinations, coral with clay, coral with tuff and coral with both tuff and clay. The results were uniform and remarkably favorable, and according to the manager of the laboratory made a better showing than the average standard brands from the Lehigh district tested by the same laboratory.

Mr. Howe appends to his report an estimate of the cost of erecting and operating a cement plant on the Isthmus, using the material noted above. This estimate follows:

AMOUNT OF RAW MATERIAL AVAILABLE.—Taking 5,000,000 bbls. as the total amount required, this would call for about 1,500,000 tons of raw materials, of which 1,125,000 tons would be of the coral, and the remaining 375,000 tons of the clay or its equivalent. That is, coral rock would have to be excavated to a depth of one yard over an area a little less than one-half of a square mile, considering one cubic yard of coral in place as weighing one ton, which is a generous estimate. A very large part of the required amount of coral could be obtained from the beach at Colon by surface excavation.

In round numbers the 375,000 tons of clay would represent the excavation of as many cubic yards by dredging to a depth of 6 ft. over an area of 100 ft. wide and 3½ miles long. Mud from the canal, Chagres, or diversions at any point below Gatun would be available for this purpose, and in amounts far in excess of those required for 5,000,000 bbls. of cement.

The weight of the rhyolite tuff is something over one ton to the cubic yard, but considering, for simplicity in calculation, that this is the equivalent weight, 375,000 cu. yds. would be required. Half as much again of this material is in sight at the west end of the railroad bridge crossing the Chagres at San Pablo, and probably four or five times this amount is available as a conservative estimate.

Speaking generally it may be said that the amount of coral is far beyond that required for twice the number of barrels of cement estimated upon, while the same is equally true of the clay and rhyolite tuff.

FUEL.—Three kinds of fuel may be used in operating the mill and in the kilns; coal from the United States, oil or local lignites. The relative cost of oil and coal is about the same at the prices now prevailing on the Isthmus, that is, $4.50 a ton for coal and 80 cts. a barrel for oil. It is believed, however, that the fuel value of the oil would be greater and its efficiency would be increased above that of the coal. The reported deposits of lignite occurring in the vicinity of Tabernilla might be considered in the manufacture of cement. Fuel of this type is of low grade and used directly would be of little value, but the high percentage of volatile matter present in the lignite could be taken advantage of by means of the gas producer, and used both in the kilns and for power.

COSTS.—The estimated cost per barrel of finished cement is as follows:

Raw material	$0.15
Coal	.48
Labor at mill	.12
Plant and interest	.39
Total	$1.34

This estimate is based on the following unit costs:

Clay or mud, dredged and delivered at mill	$0.20 per ton
Coral, delivered	.50 per ton
Coal	4.50 per ton

A plant having a minimum capacity of 1,000,000 bbls. a year would call for twelve 110-ft. rotary kilns, and would cost about $1,500,000. The item of 39 cts. for plant and interest in the cost per barrel would absorb the plant and pay interest at 6% in five years.

One of the largest costs for labor in a commercial plant in this country is for packing the cement, and this could be eliminated on the Isthmus.

All of these costs are, in my opinion, maximum ones, and might be considerably reduced in practice.

If oil were used in place of coal, taking into account the added efficiency, the price for fuel could undoubtedly be reduced to 50 cts. a barrel. A serious objection to the use of oil, however, would be the dependence of one kind of fuel, possibly from one source, and the consequent difficulty of controlling prices and insuring a constant supply.

The use of gas derived from lignite would probably reduce the cost still further if an abundance of this material of good quality could be obtained on the Isthmus. It is unlikely that a sufficient quantity of this fuel exists at points convenient for mining to justify the installation of a gas producing plant; so that should the

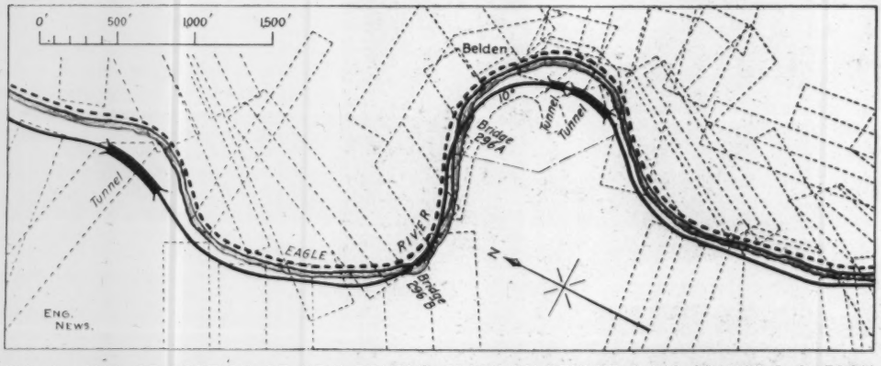

FIG. 3. MAP OF PORTION OF NEW DOUBLE TRACK ON DENVER & RIO GRANDE R. R. FROM REX TO RED CLIFF, COL.

manufacture of cement be undertaken, coal from the United States would probably be the best fuel to use.

EFFECT OF CLIMATE.—The extreme humidity existing at all times of the year, and especially in the rainy season, would probably have no harmful effect on the finished cement. If anything, the humidity would be an advantage in hastening the process of aging, which, as it is now understood, consists merely in the slaking of the free lime that is present in the cement immediately after burning.

CONCLUSIONS.—In conclusion it may be said with confidence that Portland cement equal to the best grades manufactured in the United States or Europe may be made on the Isthmus and at a cost not greater than $1.25 a barrel, and probably less.

Recent bids received for 6,000 bbls. of Portland cement, delivered at Colon, varied from $11,100 to $11,940, with an average of $11,440, or $1.91 per bbl. This was for an average delivery of 90 days.

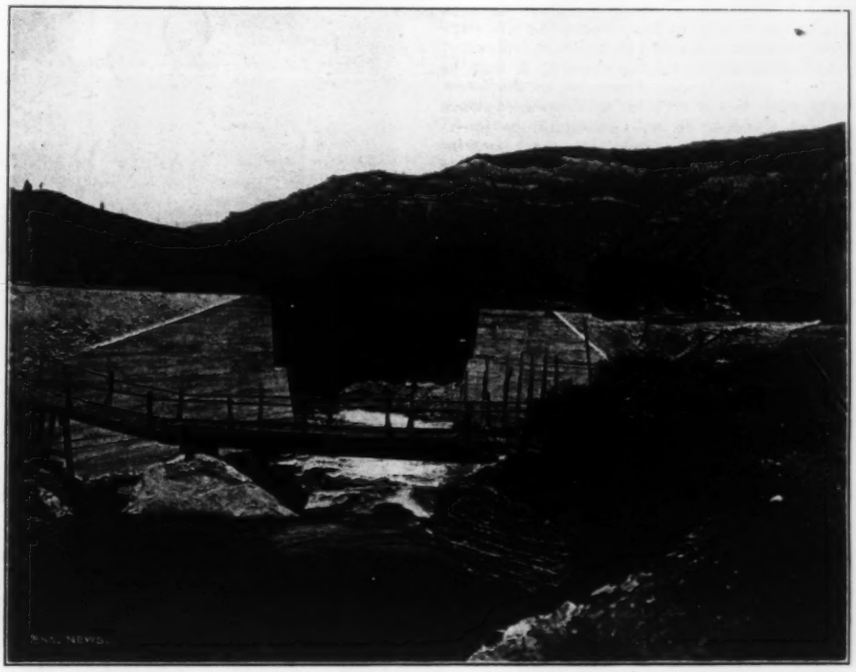

FIG. 4. HIGH CONCRETE ABUTMENT, EAGLE RIVER, COL.

THE EFFECT OF CHANGES IN CANAL GRADES ON THE RATE OF FLOW.

By F. W. HANNA.*

At every change in the grade of a canal, unless some precaution is taken to prevent it, there is a change in the water depth that produces a surface curve above the changed grade. This change in grade may be slight or it may be abrupt, as in the case of chutes, drops and checks. The nature of the surface curve will depend on whether the water depth is increased or decreased at the point of grade change. If the depth is increased, a backwater curve is produced; if it is decreased, a drop-down curve is produced. A backwater curve will cause increased water depths in the adjacent stretch of canal above the change of grade and may thereby cause overflows or decreased discharge at intake gates situated within its influence. A drop-down curve will cause decreased water depths in the canal and may, therefore, cause destructive velocities or increased discharge at intake gates situated within its influence. An accurate solution of the problem of surface curves produced by changes in canal grades is, therefore, imperative to the proper design of canals and canal structures of the type above referred to.

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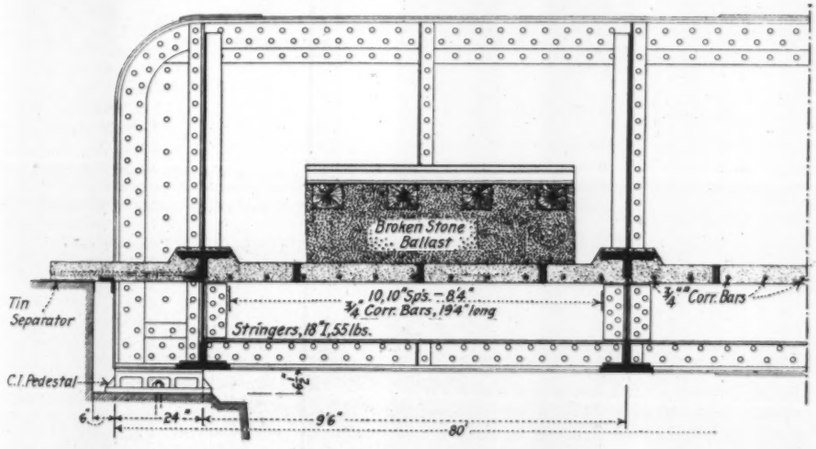
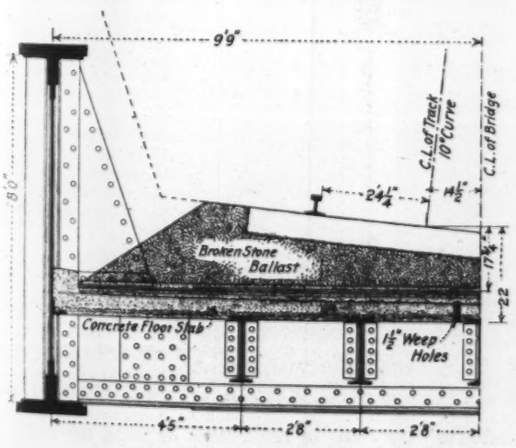


Longitudinal Section.



Transverse Section.

FIG. 5. 80-FT. THROUGH GIRDER ON DENVER & RIO GRANDE R. R.

Most of the leading works on hydraulics give formulas for the solution of this problem, facilitated in use by Breese's tables of backwater and drop-down functions, and applicable to a stretch of canal with a uniform slope of bed and with a rectangular cross section of such width that the hydraulic radius may be taken equal to the depth and the wetter pedimeter equal to the width. Since the assumed conditions as to width and hydraulic radius of the canal stretch above the change of grade are such as to make the formulas inapplicable to most of the canals with trapezoidal cross sections being built for irrigation purposes in the United States, it is the object of this article to derive a surface curve formula based on Bresse's tables that will have general application in this respect. For this purpose let the following symbols have the significance assigned them:

A = water depth in feet in canal with discharge q and slope ϕ' of water surface.
a = water depth in feet in canal with discharge q at any point in surface curve.
a_1 = water depth in feet in canal with discharge q at upper end of any stretch L.
a_2 = water depth in feet in canal with discharge q at lower end of any stretch L.

$$b = w + \frac{a_1 + a_2}{2} \cot \theta$$

$$b = w + A \cot \theta$$

c = Kutter's coefficient in any length, L, of canal for discharge of.
c' = Kutter's coefficient for canal in normal flow for discharge of.
g = gravity.
L = length of any stretch of canal above change of grade.

$$M = \sqrt[3]{\frac{q^2 p}{c^2 \sin \phi' b^3}} = \frac{b'}{b} A \sqrt[3]{\frac{c'^2 p}{c^2 p'}}$$

$$N = \frac{c^2 \sin \phi' b}{g p \cos \phi'} = \frac{c^2 \sin \phi' b}{g p},$$ when $\cos \phi'$ is taken equal to unity.

$p = w + (a_1 + a_2) \csc \phi$
$p = w + 2A \csc \phi$
q = discharge of canal in second-feet.
r = hydraulic radius in feet of canal cross section where water depth is a.
v = mean velocity in feet per second in canal cross section where water depth is a.
w = width in feet of canal bottom.
ϕ' = angle between canal bed and horizontal plane.
θ = angle of side slopes of canal cross section.

$$\phi\left(\frac{a}{M}\right) = \frac{1}{6} \log_e \frac{\left(\frac{a}{M}\right)^2 + \frac{a}{M} + 1}{\left(\frac{a}{M} - 1\right)^2} - \frac{1}{\sqrt{3}} \operatorname{arc\,cot} \frac{2\left(\frac{a}{M}\right) + 1}{\sqrt{3}}$$

The surface-curve formula will be developed in terms of the length, L, measured along the slope of the canal bed and of the depth, a, measured perpendicular to the plane thereof. L will be considered positive when measured in the direction of flow and a will be so considered when measured upward. da will, therefore, be inherently negative for the drop-down curve and inherently positive for the backwater curve; the velocity head on the other hand will have this condition of signs reversed as the velocity increases with L in the drop-down curve and decreases therewith in the backwater curve. If an elementary length dL is taken and due consideration is given to direction signs, $\sin \phi' dL - \cos \phi' da$ will represent the fall of the water surface in that length; but this fall with a like consideration of signs is also equal to the sum of the friction head and the change of velocity head in the same length. Whence Equation (1), as stated below, follows, and applies both to the backwater and the drop-down curve. Equation (2) depends on the relation of area, velocity and discharge, and on the assumption that the mean width of water area in any length, L, of the canal is a constant equal to the average of the mean widths thereof at the ends of this length. Equation (3) obtains from the definition of hydraulic radius and from the same assumption as to mean width of water area as hypothecated for Equation (2), and from a similar assumption as to the wetted perimeter of the water area. Equation (4) is obtained from Equation (2) by differentiation. Substituting v, r, and dv in Equation (1) from the three succeeding equations and solving the resulting equation for L there is obtained Equation (5). By integration of this equation the general relation between L and a is expressed by Equation (6). By substituting the indicated limits of integration there is obtained Equation (7), which is the desired general equation of surface curves. Since the slopes of canal beds are usually so flat that the depth of water measured vertically is practically equal to that measured perpendicular to the channel bed $\cos \phi'$ may be taken equal to unity and Equation (7) reduced to the form of Equation (8) with proper change in the significance of M as hereinbefore indicated. Equation (7) should be used for channels having very steep grades, as in the case of chutes and the like; Equation (8) will be less tedious and abundantly accurate for all channels with the usual grades of canals.

$$\sin \phi' dL - \cos \phi' da = \frac{v^2 dL}{c^2 r} + \frac{v dv}{g} \quad \ldots\ldots (1)$$

$$v = \frac{q}{(w + a \cot \theta) a} = \frac{q}{\left(w + \frac{(a_1 + a_2)}{2} \cot \theta\right) a} = \frac{q}{ba} \quad (2)$$

$$q = \frac{(w + a \cot \theta) a}{w + 2a \csc \theta} = \frac{\left(w + \frac{(a_1 + a_2)}{2} \cot \theta\right) a}{w + (a_1 + a_2) \csc \theta} = \frac{ba}{p} \quad (3)$$

$$dv = -\frac{q da}{b a^2} \quad \ldots\ldots (4)$$

$$L = \frac{\cos \phi'}{\sin \phi'} \int_{a_1}^{a_2} \frac{1 - \frac{q^2}{g \cos \phi' \, b^2 a^3}}{1 - \frac{q^2 p}{c^2 \sin \phi' \, b^3 a^3}} da$$

$$= \frac{\cos \phi'}{\sin \phi'} \int_{a_1}^{a_2} \frac{1 - N \left(\frac{M}{a}\right)^3}{1 - \left(\frac{M}{a}\right)^3} da \quad \ldots\ldots (5)$$

$$L = \frac{\cos \phi'}{\sin \phi'} \left\{ a - M(1 - N) \left(\frac{1}{6} \log_e \frac{\left(\frac{a}{M}\right)^2 + \frac{a}{M} + 1}{\left(\frac{a}{M} - 1\right)^2} - \right.\right.$$

$$\left.\left. \frac{1}{\sqrt{3}} \operatorname{arc\,cot} \frac{2\left(\frac{a}{M}\right) + 1}{\sqrt{3}} \right) \right\}_{a_1}^{a_2} =$$

$$\frac{\cos \phi'}{\sin \phi'} \left[a - M(1 - N) \phi\left(\frac{a}{M}\right) \right]_{a_1}^{a_2} \quad \ldots\ldots (6)$$

$$L = \frac{\cos \phi'}{\sin \phi'} \left[a_2 - a_1 + M(1 - N) \left\{ \phi\left(\frac{a_1}{M}\right) - \phi\left(\frac{a_2}{M}\right) \right\} \right] \quad \ldots\ldots (7)$$

$$L = \frac{1}{\sin \phi'} \left[a_2 - a_1 + M(1 - N) \left\{ \phi\left(\frac{a_1}{M}\right) - \phi\left(\frac{a_2}{M}\right) \right\} \right] \quad \ldots\ldots (8)$$

In equations (7) and (8) the ϕ functions and the arguments for obtaining them from Bresse's tables of backwater and drop-down functions contain relations of a and M identical with those of d and D, as usually given in connection with those tables. (See Treatise on Hydraulics by Mansfield Merriman, pp. 566-7). a, it will be noted, is identical with d not only in use but in value, while M is identical with D in use only, the value thereof being determined as hereinbefore indicated. The value of M differs from D owing to the general assumptions as to channel cross section and gradually approaches that value as a limit as the hydraulic radius approaches the depth as a limit and as the wetted perimeter approaches the channel width as a limit.

The most useful application of Equation (8) is in connection with the design of the weir for a canal drop. The question as to whether it is necessary to attempt to hold the water surface immediately above the drop at the normal depth of flow for uniform slope can be determined only by use of the formula for surface curves. If a properly designed weir of the Indian notch type is used the surface curves are practically eliminated; but this type of weir is undesirable where drift and ice may float in the canal and has not otherwise come into the popular use in this country that its merit warrants. If the control of water depth above the drops is obtained by means of flashboards, careful manipulation of the boards will eliminate surface curves; but it is interesting and essential to know how accurate this manipulation must be and what would happen if it were neglected. If it is proposed to permit the discharge to take place over the usual weir either with or without a permanent elevation of the crest thereof, surface curves will always be present and a study of their effects is imperative before designing the structure.

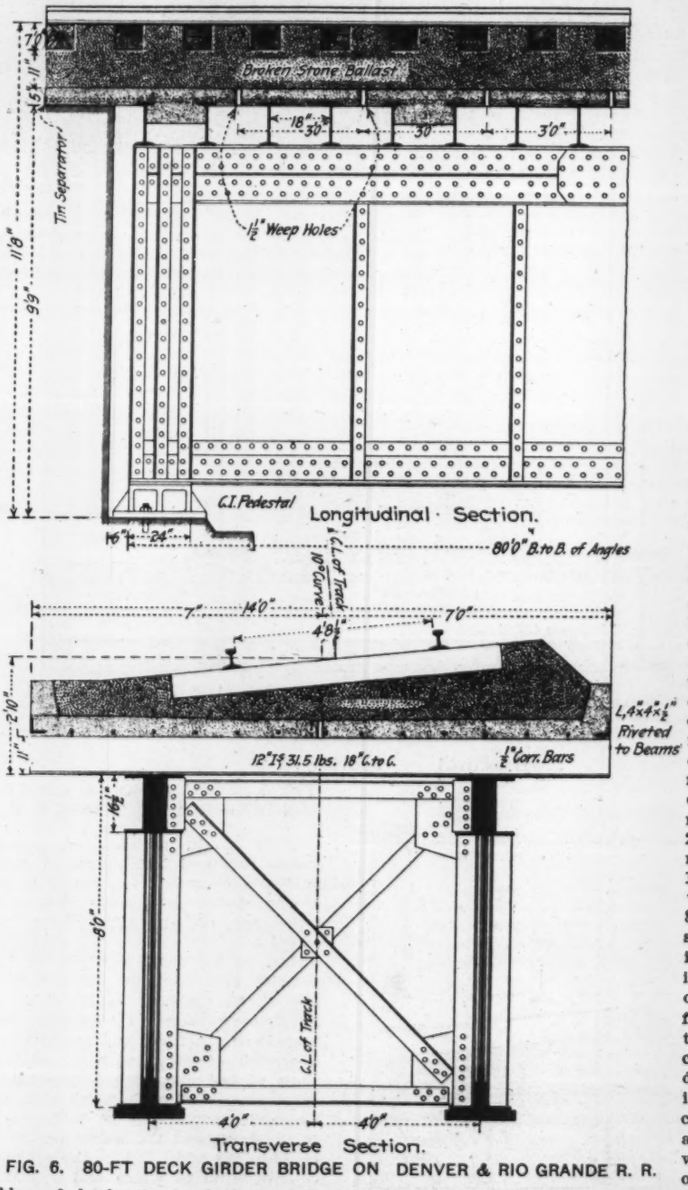


FIG. 6. 80-FT DECK GIRDER BRIDGE ON DENVER & RIO GRANDE R. R.

Illustrative of the use of equations (7) and (8) and of the necessity for such accurate formulas let there be considered a canal in operation on one of the prominent irrigation projects in the West. In this canal the following hydraulic functions obtain: Side slopes of 1½ to 1; bottom width of 18 ft.; slope of bed of 0.000154; coefficient of roughness of 0.025; depth of 13 ft. at normal flow on uniform slope of water surface; mean velocity of 2.92 ft. per sec.; normal discharge of 1,424 sec.-ft.; and a value, therefore, of 86 for c'. Let it be supposed that a drop is to be constructed in this canal, that the overfall weir therefor is such as to hold the water in the canal above it to a depth of 11 ft., that it is desired to ascertain the distance above the drop in which the mean velocity in the canal is greater than 3.3 ft. per sec. This velocity is readily found to correspond to a depth of water in the canal of 12 ft. Now by using the symbols hereinbefore explained the following values are found from the hydraulic, geometric and other

FIG. 7. BELDEN, COL., EAGLE RIVER CANYON, COLORADO.

conditions of the problem: $A = 13$, $a_1 = 12$, $a_2 = 11$, $\cot \theta = 1.5$, $\csc \theta = 1.8$, $w = 18$, $b = 35.3$, $b' = 37.5$, $c = 83$, $c' = 86$, $g = 32$, $p = 59.5$, $p' = 64.8$, $\sin \phi' = 0.000154$, $M = 13.8$, $N = 0.02$, $\frac{a_1}{M} = 0.870$, $\frac{a_2}{M} = 0.795$, $\phi\left(\frac{a_1}{M}\right) = 0.5156$, $\phi\left(\frac{a_2}{M}\right) 0.3357$. (See Bresse's table of drop-down functions). Substituting the value of $\sin \phi'$, v_1, a_1, a_2, M, N, $\phi\left(\frac{a_1}{M}\right)$ and $\phi\left(\frac{a_2}{M}\right)$ in Equation (8) L is found to be about 9,000 ft. and the mean velocity in the canal will, therefore, be greater than 3.3 ft. per sec. for a distance of about 9,000 ft. above the drop.

In finding the value of c for the stretch L of canal from a table of Kutter's coefficients the arguments have been taken as follows:—the coefficient of roughness equal to 0.025, the hydraulic radius equal to the arithmetical mean between those of the ends of the stretch and the slope of the water surface equal to the slope thereof determined from a tentatively computed value of L based on the assumption that c equals c'. A little experience in the use of the formulas will often enable the computer to estimate the value of c accurately enough for all practical purposes without solving tentatively for L for that purpose.

A solution of the foregoing problem by the formula based on rectangular channel, hydraulic radius equal to water depth and wetted perimeter equal to bottom width of channel gives a value of L nearly twice that obtained by the accurate formula herein developed. Similar discrepancies will be found between the results obtained from the accurate and the approximate formula for backwater curves. Whence the need for accurate formulas is clearly apparent, and the close student of canal design will find many practical uses for them.

FIG. 8. DENVER & RIO GRANDE R. R. NEW DOUBLE TRACK WORK ON EAGLE RIVER, COLORADO.
(Same location as in Fig. 7.)

STUDIES OF SEWAGE DISINFECTANTS.

The Bureau of Plant Industry, U. S. Department of Agriculture has within the past few years published several bulletins on the use of copper sulphate for the prevention of algae growths in reservoirs. These bulletins have also dealt with the possibility of protecting the public against typhoid and other pathogenic germs in drinking water by the use of copper sulphate. The bureau just named has now issued, as Bulletin 115, a study of "The Disinfection of Sewage Effluents for the Protection of Public Water Supplies." This bulletin has been prepared by Messrs. Karl F. Kellerman, Physiologist in Charge of Water Purification Investigations of the bureau named, R. Winthrop Pratt, Chief Engineer of the Ohio State Board of Health, and A. Elliott Kimberly, Special Assistant Engineer of that Board and Collaborator of the Bureau of Plant Industry.

Copper sulphate was tested on practically crude sewage at a convent school (St. Mary's of the Springs) of 175 persons near Columbus, O. At Westerville, O., copper sulphate was applied to the effluent from a plant consisting of septic tanks, an aerating device and double contact filters. At the Boys' Industrial School, near Lancaster, O., the same chemical was used in treating the effluent from sewage works consisting of rough screening apparatus and intermittent sand filters. At Marion, O., the copper sulphate was used on sewage from septic tanks, contact filters and sand filters.

The sodium hypochlorite, or chlorin, was used on sewage as described at both the Boys' Industrial School and at Marion.

The general conclusions are as follows:

(1) It is desirable in many instances to remove from the sewage effluent bacteria which might be considered members of the pathogenic group. This is especially necessary when sewage is discharged in the vicinity of shellfish beds or when towns and cities are so intimately related that the standard methods of water purification can not sufficiently protect one community from the sewage of another.

(2) Both calcium hypochlorite and copper sulphate have high germicidal values when acting upon partially purified sewage. Calcium hypochlorite is much more rapid in its action, is more nearly able to bring about complete disinfection at a lower cost, and is less influenced by temperature and by the presence of carbonates. It is liable to deterioration upon standing and is more disagreeable and less convenient to handle than copper sulphate.

(3) The quantity of chlorin immediately absorbed can not be estimated from the determination of the oxygen-consumed factor of the sewage effluent.

(4) The cost per annum for each 1,000 gals. of sewage treated under the varying conditions experimented with is estimated as follows:

St. Mary's of the Springs, O. (average daily flow, 12,000 gals.), crude sewage, copper sulphate, $18.55.

Westerville, O. (average daily flow, 41,000 gals.), effluent from contact filter, copper sulphate, $11.77.

Boys' Industrial School, Lancaster, O. (average daily flow, 160,000 gals.), sand filter effluent, copper sulphate, $6.93; chlorin, $5.78.

Marion, O. (average daily flow 600,000 gals.), sand filter effluent, copper sulphate, $4.86; chlorin, $2.43; contact filter effluent, chlorin, $2.73; septic tank effluent, chlorin, $8.83. In case the effluent from the septic tank contains much suspended matter a heavier application of chlorin is necessary.

These figures probably approximate the cost for treatment in any city whose sewage is not markedly influenced by industrial wastes. In the small plants here discussed depreciation has not been included in the cost data; it is, of course, a factor which must not be overlooked for operating cost on a larger scale.

REPORT OF THE TRANSVAAL COMMISSION ON THE USE OF WINDING ROPES, SAFETY CATCHES AND APPLIANCES IN MINE SHAFTS.

(*Continued from our last issue, page* 511.)

Fracture of Winding Ropes, Safety Catches, Etc.

143. In the statistics published hereunder, it will be seen that the only instances of the successful operation of safety catches occurred at the time of overwind on the up-trip. These may be supplemented by the three similar but later cases mentioned in paragraph 124:

ACCIDENTS IN WHICH THE ROPE OR CONNECTION BROKE.

Total number of accidents 51, of which 13 were fatal.

Accidents due to faulty ropes	8
Accidents due to faulty connections	10
*Accidents due to other causes which broke rope or connection	33
Total	51

Of these 51 accidents, the cage or skip was fitted with safety catches in 9 cases, 2 of which were successful and 7 unsuccessful.

Cases in which an efficient safety catch would have saved life	13
Cases in which an efficient safety catch would have saved property	28
†Cases in which an efficient safety catch would have been useless	10
Total	51

144. The two instances in which the safety catches acted successfully were on the up-trip; the engine-driver overwound the skip and broke the rope, as no detaching hooks were fitted.

145. Of the 7 instances of unsuccessful operations quoted above, 2 were on the up-trip and 5 were on the down-trip. Three were cases in which the cage reached the bottom of the shaft before the rope broke. In 1 case the supplementary safety chains supported the load; so that in this and the 3 preceding cases, the catches did not have a chance of coming into operation, the king-bolt spring remaining compressed. In 2 cases the cams of the safety catch were not properly designed, the angle of the wedging action being too great.

146. In paragraphs 19 to 25 of this report, the historical side of the safety-catch question has been dealt with; and from a study of this section, the references quoted, and statistics of shaft accidents generally, there can be no doubt in the mind of any person as to the necessity of using a reliable safety catch, if such an appliance exists. However much stress is laid on the necessity for securing the best possible winding rope, and for its being carefully and intelligently examined during its working life, it must be evident to all that a good sound winding rope is not, by itself, a sufficient safeguard.

147. Statistics conclusively show that safety catches of themselves are not necessarily an additional source of danger to persons traveling in mine shafts, while on the other hand they have saved life on many occasions.

148. From the commencement of its work, the Commission has taken up this attitude, and has worked on with the idea of establishing the reliability of selected devices.

149. The Regulation‡ dealing with the use of safety catches states that, except during sinking operations, they shall be provided where applicable; and it has been customary for this reason, in the Transvaal, to exempt cages, skips, and other conveyances working in inclined or compound shafts, or in vertical shafts fitted with steel guides. Reserving for future consideration the cases of inclined and compound shafts, the Commission noticed at once that the safety catches used in vertical shafts were not in any way reliable; and while the use of steel guides was generally increasing as deeper levels were opened out, no suitable safety catch was put forward to meet this growing need.

150. Seeing that wire-rope conductors were but little used in the Transvaal, and that their very limited use was not likely to extend, the inquiry was also justifiably limited to meet this circumstance.

151. Of the 84 designs submitted, the Commission selected 5 for trial, 2 of which were presumably equally applicable for conveyances traveling on wood or steel guides. In the latter category were placed the Wilkinson and Schweder devices, while the Undeutsch, Hughes and Garvin appliances were, in the submitted designs, only suitable for timber guides. Jensen's safety catch, for use with steel guides, was favorably noticed, but the working drawings came to hand too late for the device to be tested practically. Thomson's safety catch, which was not selected by the Commission, was, however supplied in working shape by the inventor, and the trials were witnessed and reported on.

*These accidents were due to overwind, skips being derailed, engine driver losing control of engine or drum, rope jumping pit-head sheaves, truck coming loose in cage, skips jamming in shafts, etc.

†These cases include skips coming off the track on the incline and those in which the drum had become disconnected from the engine, the engine-driver losing control and the skip going to the bottom of the shaft before the rope broke.

‡Article 40 (k); to be published later.

152. [An abstract of the details of these tests, digesting briefly and broadly the data given in the "annexures" to the report, and including drawings of the most important of the catches, will be given in next week's issue. —Ed. Eng. News.]

153. In justification of the Commission's selection, and in explanation of the failure of more than one of the appliances, the following remarks with respect to the necessities of a good safety catch are put forward:

154. The selected designs did not, in every case, possess all these qualities, but it was considered desirable to test them, either to prove that they did not do so, or to establish, practically, the necessity for these attributes.

(1) The instantaneous release of tension in the rope, at the time of its fracture, must immediately be taken advantage of through the medium of some spring connection (not necessarily metallic) to operate, by one means or another, the retarding agency. The releasing of a weight without any spring impulse is not likely to be effective, as it is difficult to attempt to disturb in this way the natural zero relative motion of all the moving masses.

(2) The movement of the spring can be best utilized to create a small relative motion of the draw-bar (king-bolt) of the cage.

(3) The motion of the draw-bar should be utilized to work the brake mechanism in a manner so far non-reversible that, once the brake is in action, it will require an actual raising of the cage, or a rope-pull equivalent to it, to release it in the slightest degree.

(4) The tension in the spring should be as small as possible—certainly not more than half the weight of the empty cage—so that the catches shall not be brought into action, when not required, by the pulsations of the winding rope.

(5) Seeing the instantaneous nature of the operation, and the small force disposable to effect it, the weight of the actual moving parts should be reduced to a minimum.

(6) The force necessary to produce any retardation in a pulling body must be at least equal to the weight of the body itself. If this force is only equal to the weight of the body, then no retardation occurs, the force of gravity is exactly neutralized, and the body continues in uniform motion downwards with the velocity it possessed at the instant of the application of the force. It is therefore necessary to supply something more than this, if the body is to be stopped.

The difference between the catching force (supplied by the safety catch) and the weight of the loaded cage is the amount available for retardation. On the amount of this difference, and on the suddenness of its creation, depends the shock to the occupants of the cage and also the braking distance, this latter being also influenced by the velocity of the cage, the relation being directly as the square of this velocity.

The retarding action of a good safety catch should therefore conform with these principles, and ensure the arrest of the cage, even on the downward journey, without injury to the occupants.

(7) The retarding force, whether produced by deformation and friction with wooden guides, or by friction on steel guides, should be, within practical limits, independent of the amount of reduction in size due to wear that the guides have previously sustained.

(8) The direction of application of the retarding force should be such that the guides and their supplementary framework are maintained in position.

(9) The safety catch, having stopped the cage, should maintain it in position until it is again lifted.

(10) The safety catch should be equally reliable in its action whether the rope breaks on the ascending or descending trip.

(11) The mechanism should be capable of ready examination, and designed with due consideration to the severe working conditions that it has to meet with in mining practice.

155. With reference to condition (6) mentioned above, the question of what is a safe braking distance is not yet answered. A man, if prepared, can fall several feet without injury, but a small distance taken inadvertently may produce injury. For use in the tests at the Marcus shaft, a shock-meter was prepared and calibrated on the free fall system to indicate the extent of sudden arrest. With a 2-ton cage falling at the rate of about 1,200 ft. per min. and stopped in 2 experiments in 13 ft. and 15 ft. 5 ins. respectively, the indicator showed 4.4 ins. and 3.25 ins. Practically the same result was obtained, considering slightly altered adjustment of the safety catch to suit worn guides, with a greater velocity and a longer travel.

156. These measurements of the indicator represent the suddenness with which the full braking action of the safety catch is developed, bearing in mind that the braking action is equal to the excess of the maximum catching force over the weight of the loaded cage.

157. These values, varying from 3.25 ins. to 4.4 ins. with the Garvin and Undeutsch safety catches when the total load was 2 tons, show that these devices, if properly adjusted, are not likely to cause serious injury to persons; and that they will bring the falling cage to a standstill in a reasonable distance, say from twelve to thirty feet, this amount of travel depending on the downward velocity of the cage at the time of rope fracture. Both these safety catches are adjustable so far as the shock is concerned, provided that the guides do not vary appreciably in width at different places in the shaft. In the case of the Undeutsch catch, from the shape and arrangement of the knives it is not probable that a variation of a half-inch in the width of the guides, involving a quarter-inch variation in the penetration of the knives, will cause much alteration in the shock.

158. The Garvin safety catch fails in this respect, and, until automatic adjustment of the penetration of the wedge faces is provided for, it cannot be regarded as a satisfactory device. This automatic adjustment can be provided for in a fairly simple manner, but not in so complete a way as to prevent increase of [illegible] if the falling cage suddenly meets a guide which is [illegible] than the one just passed over.

159. In the Schweder catch, the brake [illegible] having an elastic gas backing, there is produced [illegible] catching pressure which is practically independent of [illegible] width of the guides. Although the registered [illegible] were the same, and the loaded cage was considered [illegible] lighter in the Schweder experiments than when the [illegible] Undeutsch catch was tested, there was a considerable [illegible] ence in the braking distance. To reduce the braking [illegible] ence in the case of the Schweder catch will probably [illegible] ve an increase in the shock, but this can be kept w[illegible] a safe margin by adopting in the design of the [illegible] catch such dimensions and narrow pipe connections [illegible] ports as are suitable for the particular circumsta[illegible] of a specific case. With reference to condition [illegible] the Schweder device, as tried at the Marcus shaft, did not exactly comply with this desideratum, in that the slight leakage of gas from the cylinders after the catch had come into operation was found to lead to a reduction of the gas pressure, and consequently to the loosening of the grips and freeing of the cage—this happening after a lapse of time of, perhaps, half an hour's duration. The inventor, however, has now designed a supplementary arrangement which, operating by means of a spring acting against gas pressure, causes a small roller to be brought into action after the gas pressure has fallen below a certain limit and thus effectually holds the cage until it is lifted away again.

160. With regard to condition (10),* no special trials were made of the selected devices on the up-trip. Incidentally, during the trials of detaching hooks it was several times proved that a mechanically operated safety catch, if properly designed and maintained in proper working order, can always be counted upon to meet this condition, viz., that of the rope breaking while the cage is being raised. The Schweder device was also considered to be perfectly reliable in this respect, and with respect to any possible danger arising from its untimely action which might be brought about by the pulsation of the rope while the load is being wound upwards, it has only to be remembered that the exhaust from the brake cylinders is quite as rapid as the inlet of gas; in fact it is practically instantaneous, so that there is no possibility of the rope being overstrained on account of the brakes maintaining any grip after the king-bolt spring has been compressed. The valve will open to exhaust just after compression of this spring starts, and the gas pressure in the brake cylinders will be relieved before the act of compression is completed.

161. The ordinary White & Grant eccentric safety catch was tested in order to demonstrate finally its unreliability.

162. Several devices were rejected because they were obviously too sudden in their action, and would give too much shock if called into action on the down trip.

163. A number of ingenious devices were not recommended for trial because they were of the "delay-action" type, and did not immediately neutralize the force of gravity. They were not sudden enough in their action, their inventors clearly not fully appreciating the laws governing the motion of falling bodies.

164. Other designs of safety catches proposed to minimize shock by means of pneumatic, hydraulic, or spring buffers built into the frame of the cage. It was considered that this principle, which had already been tested successfully in Germany, was not to be recommended owing to the great increase in weight which such a safety catch would entail if a suitable braking distance were provided.

165. The trials of the Hughes, Thomson and Wilkinson devices proved unsuccessful. The tests of the last-mentioned safety catch in large model form gave promise of its suitability for use on steel rails, but defects in the design of the model of working size entirely disposed of all chance of success. To remedy these defects would have been very expensive, and the trials disclosed the probability of the fickleness of the device unless especially adjusted to suit any small alteration of working conditions. Owing to the complete success of the Schweder catch when used on the steel rails, further trials of the Wilkinson catch were abandoned.

166. Seeing that the possibilities of a satisfactory safety catch for vertical shafts have been established, the Commission recommends that the present Regulation† shall remain in force, and that the question of the applicability of any particular safety catch should be left to the Government Mining Engineer to decide.

167. In the same manner that the British Board of Trade permits the use of certain safety valves for marine boilers, and just as the British Home Office has published a list of permitted explosives for use in coal mines, so, it is considered, should the Mines Department prescribe which safety catches are to be classed as suitable for the various kinds of shaft.

168. The Commission, while not wholly satisfied that any of the safety catches tried entirely meet the require-

*Paragraph 154.
†Article 40 (k).

ments of such an appliance, considers that, of the designs submitted, the following give the best results:

For vertical shafts with wooden guides, the Undeutsch; for vertical shafts with wooden guides, the Schweder; for vertical shafts with steel guides, the Schweder; and for inclined shafts with steel rails, none at present; the Commission advises early trials of suitable designs.

169. The special conditions obtaining in each compound shaft should be investigated by the Mines Department, and a decision arrived at in each case regarding the applicability of safety catches.

170. The Commission recommends that no safety catch should be placed on a "permitted" list until its reliability has been thoroughly established by tests similar to those carried out at the Marcus shaft—such tests to be conducted at Government expense and under the direction of the Government Mining Engineer, with previous advertisement in the daily press. It is also considered

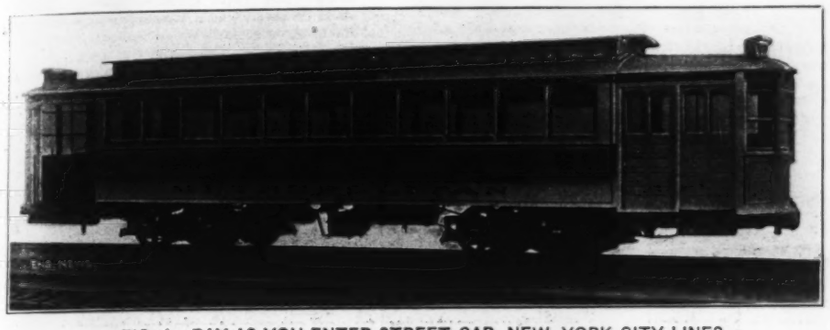


FIG. 1. PAY-AS-YOU-ENTER STREET CAR, NEW YORK CITY LINES.

that the inventor should supply and deliver at the testing station, free of cost to the Government, the full-sized working appliances ready to be fitted to a cage of standard dimensions.

GENERAL SAFETY MEASURES.

171. Some other points likely to affect the safety of persons were touched upon by Mr. Robert Briggs, one of the oldest engine-drivers on these fields. He represented the South African Engine-Drivers' and Firemen's Association, and in this capacity spoke in favor of extending the list of authorized signals, of isolating the winding engine from all other machinery, and of bringing into general use a bell signal recorder. He also spoke in condemnation of barrel indicators as causing constant strain on engine-drivers' eyes, and was averse to the use of the chain drive for operating the depth indicator.

172. The Commission considers that it is inexpedient to increase further the list of authorized signals to the extent suggested. Owing to the various kinds of mines and the different kinds of shafts, complete standardization in the matter of signalling is impossible. There appears, however, no objection to, and considerable reason for, universal signals in the cases of transport of explosives, notifying accident or emergency, and request for repetition of signals.

173. The isolation of the winding engine is a very necessary thing so as to keep the driver as free as possible from distracting influences, but there are practical difficulties in some cases which prevent this custom being universally adopted. The Commission is, therefore, unable to recommend that this practice shall be established absolutely by the regulations. The Inspector of Mines, at the present time, has the power to insist on isolation where necessary,* and the Commision considers that this provision is satisfactory.

174. With regard to the use of a bell signal recorder, the Commission considers this very desirable, but, from the very limited experience with any such apparatus, it is considered premature to make this a compulsory attachment to each winding engine.

175. Concerning depth indicators, there can be no question that the dial and the pillar types are in most general use, and that they afford to the driver the clearest and most precise indication of the position of the vehicle in the shaft. A very necessary stipulation should be made, however, viz., that the travel of the pointer between the "tip" and the extreme bottom of the shaft should not make a complete revolution, within three inches, on the circumference of the dial. The barrel type of indicator should always be so arranged that the pointer, while giving a fine reading in conjunction with the spiral grooves, also provides a rough indication in its own vertical guide. Regarding Mr. Briggs' objection to the chain-driven indicator as being unreliable, the same objection also applies to bad examples of other forms of drive. A good chain and sprocket gear is universally recognized as being a sound mechanical device, although requiring, perhaps, more attention in the way of adjustment that toothed gearing; and there is, therefore, no reason for prohibiting its use.

*See Article 155 (e), Mines and Works Regulations.

SINKING WITH BUCKETS OR SKIPS.

176. A considerable amount of evidence was taken as to the relative advantages of the use of buckets or skips in the sinking of deep shafts, the Commission being anxious to obtain the best opinions as to the safest methods of deep-level sinking—a subject which has caused a large amount of discussion during the past three years.

177. From the evidence before the Commission, it is not possible at present to advise upon any hard and fast regulations dealing with this matter; the question of whether buckets or skips are least dangerous depending largely upon the personal element in actual working and supervision and upon details of ropes and winding plant.

178. Until recently, sinking with buckets has been the method most employed, and the number of recorded accidents show that a considerable amount of danger attends this method of sinking. The use of buckets has been rendered safer by the use of the Berry crosshead (See Fig. 7), and the Commission is of the opinion that an approved crosshead is essential in this method of sinking.

179. The Mining Regulations* prohibit persons riding on the top or rim of a loaded bucket, and the Commission considers that this regulation should apply to empty buckets as well, in order to avoid an unevenly balanced load swinging in the shaft, and also to prevent any accidents due to the clothes or bodies of persons riding on the bucket rim catching on the shaft timbers. In addition to this extension of the regulations, the Commission considers it necessary that a loaded bucket should, when being raised to the surface, stop when the crosshead is picked up; and that it should be rung away by signal from this point of stopping, so as to ensure a steady lift to the surface when the engine-driver puts on speed.

180. The use of sinking skips is, from a safety point of view, superior to that of buckets; but, while not giving so many opportunities for hoisting accidents, it can also be a source of considerable danger. The long runners on a sinking skip are a great disadvantage, there being a difficulty in giving a sufficient clearance between the long runner and the guide; and, on occasions, serious shaft accidents have been caused by the skip sticking in the shaft when being lowered or raised on the long sinking runners.

181. In face of the recorded number of accidents with sinking buckets, as shown in the Mines Department annual returns, deep sinking with skips is to be recommended as the safest method, inasmuch as a guided skip, not having the freedom of the sinking bucket, is effectively fixed in the shaft; is unable to swing, spin or strike the walls of the sinking compartment; and is not so much dependent upon careful hoisting, or the initial steadying of the load to be raised, as in the case of a sinking bucket in shafts that are not close timbered.

182. In placing our report in the hands of Your Excellency, we desire to express our recognition of the responsible work which has devolved upon the Secretary, Mr. J. R. Mackinlay, who has rendered us material assistance by the energetic and zealous manner in which he has performed his duties. Our thanks are also due to Mr. W. Martin Epton, Government Inspector of Machinery, and to Mr. J. A. Yule, Engineer of the Langlaagte Estate and Gold Mining Co., Ltd., for the very valuable services rendered by them in carrying out the practical tests at the Marcus shaft, and for the information supplied by them for this report.

*Article 48, 5 (f).

[We give below in full the names of the signers of the report, with their official connections.—Ed. Eng. News.]

U. P. SWINBURNE, Acting Government Mining Engineer (Transvaal), Chairman.
WAGER BRADFORD, Manager, Langlaagte Deep Gold Mining Co., Ltd.
H. C. BEHR, Consulting Mechanical Engineer, Consolidated Gold Fields of South Africa, Ltd.
J. F. COOK, Consulting Mechanical Engineer, S. Neumann & Co.
E. FARRAR, Consulting Mechanical Engineer, General Mining and Finance Corporation, Ltd.
J. S. FISHER, Inspector of Mines, Johannesburg.
GEORGE C. FOX, Consulting Mechanical Engineer, A. Goerz & Co., Ltd.
DAVID GILMOUR, Consulting Mechanical Engineer, Johannesburg Consolidated Investment Co., Ltd.
J. A. HEBBARD, Manager, Langlaagte Estate and Gold Mining Co., Ltd.
FRED HELLMANN, Consulting Engineer, East Rand Proprietary Mines, Ltd.
W. L. HONNOLD, Consulting Engineer, Consolidated Mines Selection Co., Ltd.
EDWD. HOPPER, Consulting Engineer, Representing the Transvaal Chamber of Mines.
J. HARRY JOHNS, Consulting Engineer, Johannesburg Consolidated Investment Co., Ltd.
C. J. PRICE, General Manager, Central Administration.
A. M. ROBESON, Consulting Mechanical Engineer, H. Eckstein & Co.
H. ROSS SKINNER, Manager, Durban Roodepoort Gold Mining Co., Ltd.
J. W. H. STUBBS, General Manager, Randfontein Estates & Gold Mining Co., Ltd. (Witwatersrand.)
S. C. THOMSON, Consulting Engineer, S. Neumann & Co.
J. A. VAUGHAN, Chief Inspector of Machinery (Transvaal).
EDWARD J. WAY, General Manager Kleinfontein Group of Mines.
Johannesburg, May 7, 1907.

(*To be Continued; see paragraph* 152.)

"PAY-AS-YOU-ENTER" CARS FOR NEW YORK CITY STREET RAILWAY LINES.

In an attempt to improve the traction service in New York City, a new type of car will be placed in operation on the Madison Ave. line of the New York City Railway Co., as has already been announced, in December of this year. The later announcements that several hundred of these cars will also be placed in service in Chicago and in Buffalo have aroused considerable interest in the construction and arrangement to be employed. The cars herein described and illustrated are those intended for use in New York City, and may be considered typical of the general development.

In Fig. 1 the outside appearance of the car is shown. The general arrangement is indicated in the plan, Fig. 2. The total length of the car is about 48 ft., or about 11 ft. longer than the present standard closed car. The car is also slightly wider than the present standard equipment of the New York City Railway Co. For the purpose of greater comfort to passengers, and in order that less time may be consumed in making stops, entrance is restricted to the rear platform, although persons may leave the car at either end; thus, as will be seen by referring to the floor plan,

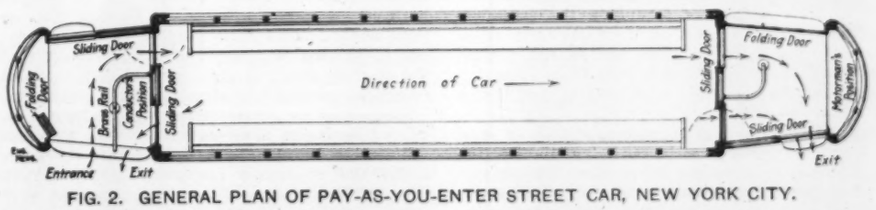


FIG. 2. GENERAL PLAN OF PAY-AS-YOU-ENTER STREET CAR, NEW YORK CITY.

the annoyance and delay, created by the attempt of one set of persons to leave the car through the same space as that by which other persons are seeking to board the car at the same time, is eliminated. Persons who desire to enter the car may do so at the point marked "entrance," stepping upon a commodious platform 7 ft. 6 ins. long by approximately 6 ft. broad. They then move, in the direction indicated by the arrow, Fig. 2, past the conductor, who stands at the point shown, to whom the fare is paid as the passenger enters the car. As soon as all of the passengers have stepped upon the platform (which will hold more than 20 persons), the con-

ductor, who always maintains the same position, gives the signal to the motorman to proceed, and the passengers enter the car from the platform as soon as the fare has been paid. In order that there may be room upon the platform for persons who may board the car at the next stopping-place, passengers will not be allowed to remain standing upon the rear platform.

Fig. 3 shows the rear platform of the car, which, it will be seen, is enclosed on three sides. Ample protection from the weather is afforded persons while they are on the platform. Fig. 4 shows the view taken from the front of the car, and with the adjustable rail lowered so that passengers may leave the interior of the car by the door on the left or the door on the right as they may elect.

By a small push button in the woodwork between the windows, a passenger desiring to leave the car can communicate his wishes to both the conductor and motorman at the same time, as the car is approaching his destination.

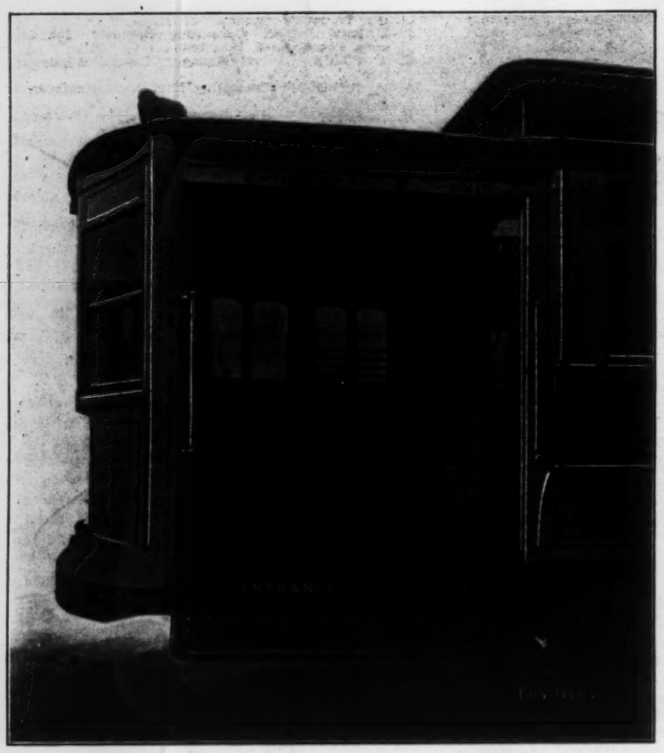


FIG. 3. REAR PLATFORM OF PAY-AS-YOU-ENTER STREET CAR.

FIG. 4. FRONT PLATFORM OF PAY-AS-YOU-ENTER STREET CAR.

It is optional with the passenger as to whether he will leave the car through the sliding door at the rear or through the swinging or the sliding door at the front of the car, as shown on the floor plan. This method of arranging the entrances and exits practically affords facilities three times as great as those provided for on the present standard closed cars. It is seen from these figures that the car ends are duplicates, and that a car may be shifted to a parallel track for its return trip without going around a loop or upon a turntable. Of course in reversing its direction of motion for a new trip the barriers between exit and entrance areas have to be removed and replaced on the former rear and front ends respectively. At the same time, on the end formerly front, the outside sliding door is to be fastened and the folding doors are to be opened, while at the other end the reverse operation is necessary.

The aisle within the car is about 6 ins. broader than in present practice, and there will be an unobstructed view both forward and backward along the streets through plate-glass windows in the sliding and swinging doors at each end of the car. Glass is also placed in the stationary portion of the end of the car body between the sliding and swinging doors. For night illumination there will be three rows of incandescent lamps in the ceiling, one row being in the center and one on each side ceiling. For the greater convenience of patrons, an experiment will be made with a colored light signal displayed upon the front of the car, and indicating by various blue, green, yellow, red or white lights, the destination for which the car is bound. Each car will be equipped with both air and differential brakes. As a further matter of safety, the electrical equipment is so installed that it may be used as a powerful brake if desired.

It is obvious that a car of this character is much heavier than the present closed cars, and partly because of this it is expected that the stopping and starting of the car should not be attended with discomfort, and that the movement of the car will be more uniform and pleasant. It is hoped that the use of these cars will sufficiently systematize the entrance and exit of passengers as to shorten the time now consumed in stops. There will be no necessity for the conductor to continually pass and repass through the car, a course always likely to be attended with more or less annoyance to passengers. By reason of the conductor's position, he will always be able to definitely assure himself that all persons desirous of either entering or leaving the car have accomplished their purpose before the signal to proceed is given, and the likelihood that the starting signal be given prematurely by some impatient passenger is almost entirely eliminated.

Many persons whose testimony should be regarded as expert have maintained that it is impracticable to operate a car of this character under the conditions prevailing in New York City, although its use has been attended with great success in Montreal. One predicted difficulty is that passengers will not have the exact fare ready for the conductor, and that one person will be able to delay the entrance of several others while he hunts for the fare or while the conductor makes change. However, unless over 20 persons were boarding at once from the plan of the car it would seem that there was ample space so that a person having some difficulty in locating his small change or one offering a bill of large denomination could be made to stand slightly aside while the others paid and passed through. A few experiences of this sort would teach a person to make an effort to have the fare ready. If one notices the crowd in an elevated or subway entrance in New York City, it is observed that the fare is usually ready before the ticket booth is reached. It would seem possible that the street crowds could learn the necessity of similar promptness in using the surface lines equipped with cars of this type.

THE MANUFACTURE AND USE OF STEEL RAILS—PROPOSED CHANGES IN SECTION.*

By FRANKLIN E. ABBOTT.†

There is a great advantage gained by both makers and users of steel rails from the modern practice of always keeping ingots in a vertical position, from the time they are cast till the metal has been brought to proper consistency for rolling.

In nearly all specifications for steel rails, there is a short clause which reads about as follows: "No bled ingots shall be used." This restriction, so much needed in old methods, is of little or no account at the present time.

In the early days of rail making, it was the practice to throw ingots on their sides as soon as they were taken from the molds, and, in fact, they were kept in that position in the reheating furnaces. If, by chance, the surface crust at the ends should break open, the fluid metal at the center of the mass would bleed out, leaving a hole which would almost certainly result in piped rails.

The longer time given under the present practice for the metal to solidify in the molds, and always keeping the ingots in a vertical position in the reheating furnaces, practically eliminates all possibilities of any bleeding, and in a corresponding degree makes a protection against getting piped rails in the product.

When the ingot is turned down on its sides for the first time, it enters the blooming rolls. The first two passes are through two separate sets of rolls of large diameter, operated by powerful engines. The motion is slow, and the reduction heavy. It then moves forward to the next set of rolls, where four passes are made and a bloom about 8 ins. × 8 ins. and 20 to 22 ft. long is completed.

In these shapes, the size of the bar is reduced sufficiently so that the ends can be sheared off. Enough metal is cut from the end coming from the top of the ingot to remove all traces of piping or spongy steel, and also removes the part containing greatest amount of segregation. From the other end, coming from the bottom of the ingot, enough is cut off to make the end face square and solid.

After the shearing, the bloom is conveyed to the roughing rolls where in four passes a rough form of the rail section is worked out. From there the bar goes to the

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finishing rolls, making four more passes, thence moved sidewise across the mill floor to the last finishing pass, where the rail section is finally completed to the minute refinement of its detailed dimensions.

The block of steel which started at the other end of the mill, about 18 ins. square and 50 ins. long, has now become a rail with a sectional area of 6 or 7 sq. ins. and 75 ft. in length. All this change has been made in an interval of eight to nine minutes. In a two-high mill, such as the one referred to in this paper, the ingot is continued throughout the entire rolling process in one piece, and finally a single length is furnished equal to four or five 33-ft. rails.

The long rails is carried from the last finishing pass to the hot saw, where it is cut into standard lengths, according to order, cutting one rail at a time, thence through the cambering rolls to the cooling beds, where the rails are left till brought to the temperature of the atmosphere or about seventy degrees.

In passing through the cambering rolls the rails are forced into a curvature with the head arching upwardly. That is to say, if the rail, immediately after coming out of these rolls, were made to rest on its base, or in the track-man's parlance, "work ways," the ends would be low. From this shape it warps first to the opposite curvature, bringing the ends high, then back toward the first shape and finally draws back again in the final cooling, leaving the rail, when resting freely on its base with a back sweep or the ends up.

The effort on part of the mill superintendent is to regulate the cambering so that the rails will cool as nearly straight as practicable, but as absolute straightness is almost impossible to attain, they are preferably brought, when cold, to a slight back sweep as already described.

There are two reasons for having rails at their normally cold temperature with back sweep rather than head sweep, if they do not come out perfectly straight.

First. The cold straightening work will be done mainly on the base, thereby escaping the danger of indentations from the gagging iron on the running surface of the head.

Second. The internal stresses left in the rail when it becomes cold, tending to draw the ends upward, even after it is cold straightened, will help to hold the joints up and maintain better track surface when the rails are put into use.

The rails pass from the cooling beds over live rolls, by which they are distributed to the presses, where they are straightened, drilled, finished and inspected, thence they are carried down through the mill to the loading sheds and finally loaded on cars.

This completes a general outline description as to how rails are made. But before going on with the third step, the use of steel rails, it may be of interest to return to some points along the process of rail making where greatest difficulties are encountered, and also cite some of the articles in standard specifications that are a source of more or less contention between the makers and users.

One such matter is the chemical composition. When the spiegeleisen is poured into the purified iron in the converter just after the blow, necessary ingredients are introduced to make it hard, elastic and ductile. Chemical analyses of average Bessemer rail steel as made at present for heavy rails run about as follows:

Carbon	.50%
Phosphorus	.10%
Sulphur	.08%
Silicon	.12%
Manganese	1.00%
Iron	98.20%
	100.00%

The quantity of carbon can be controlled by the grade of spiegel used. The makers and users of rails are not exactly agreed as to what the limits in carbon should be. The users have been inclined to increase carbon content somewhat faster in proportion than the increase in weight of rails. When a 70-lb. rail was regarded as a heavy section, carbon in the steel ran from .35 to .40; but when the weights of rails reached 100 lbs. per yard, .60% carbon was called for, and in some cases the upper limit was fixed at .65%. The higher carbon steel, 55% to 65%, was also specified for lighter rails such as 80-lb. and 85-lb. per yard. The 80-lb. rail was an increase in weight of only about 14% over the 70-lb., but .58% carbon often called for in this weight rail was an increase of fully 45% of this element over the lighter section. It can be seen that hardening properties were raised entirely out of proportion with the increased weight, and the apparent consequence was a less satisfactory rail in the heavier section.

The reason for raising the carbon was to get more elasticity and better wear, which in a degree was obtained, but with it came more failures from breakage. It was then proposed and specified on part of the users that phosphorus should be lowered about 15%, making the limit not to exceed .085%. This proposition seemed entirely consistent from a metallurgical and theoretical standpoint, but practically it cannot be obtained because of the ore conditions.

The available .085 phosphorus Bessemer ores in the United States are relatively small. If all the rail mills in this country were to undertake to fill, from American ores, the annual requirement of about 3,000,000 tons under .085 phosphorus specifications for Bessemer rail steel, that grade of ore would be exhausted before provisions could be made to meet the yearly demand for rails made by any other process.

If open-hearth steel is to succeed Bessemer, it will take a term of years and the expenditure of an enormous sum of money to build furnaces enough to provide the steel needed for rails alone. Before this could be accomplished, it is more than probable that the .085 phosphorus Bessemer ores would run out, and with an inadequate production of open-hearth steel, the railroads would have to either get along with a short supply, or import the tonnage lacking. In the event of such sources not being able to keep pace with the demands, their only alternative would be to take a grade of Bessemer steel far inferior in wearing qualities to what they are now getting.

To avoid this apparent short cut to the end of good quality Bessemer rail steel, the makers insist that the phosphorus limit shall be left as it has been for a number of years past at 0.10%, and a somewhat modified carbon content be used. It is entirely practicable to use enough carbon with 0.10% phosphorus ores to make perfectly sound, safe and serviceable Bessemer steel, and with that limit accepted, the manufacturers will be able to produce good quality Bessemer steel rails for many years to come.

The wear of the heavier section rails has not been all that the users expected, even with the proportionally higher carbon, and they are loath to make any recession in this hardening element, fearing that by so doing, there will still be greater loss from rapid wear. But the question of safety must have first consideration, and neither the makers nor users of rails will be justified in adding hardening properties, to get increased service, that will place the material anywhere near the danger line of breakage.

Thus the question of carbon and phosphorus content that shall be used in Bessemer steel for rails is not fully and definitely settled. The phosphorus limit is substantially fixed by conditions. The carbon limit to correspond is likely to be fixed by more experience. There is a strong probability, however, that harder steel may be used if the shape of the rails is changed. How this may be brought about will be considered further on.

The next element in order in the steel composition is sulphur. This is of little consequence to the user of rails. Its effect is to make hot steel dry, or what is called "hot short," and liable to pull apart, making flaws on the surface of rolled shapes. A limit of 0.10% can be handled very well, but it is always to the interest of the manufacturer that it should be lower.

Silicon has a quieting influence in molten steel when it is settling and cooling in the molds and makes it dense when cold. A limit of 0.20% is generally stated in specifications.

The quantity of manganese in rail steel will run from 0.80% to 1.10%. Its effect is to make the hot steel tougher, overcoming some of the bad effects of sulphur, and thereby better adapted to rolling. It also makes the steel harder and better for wear, but if the quantity exceeds very much the upper limit noted it is liable to lead to brittleness.

Another clause in standard rail specifications that is a source of some contention between makers and buyers of rails, reads as follows: "Sufficient material shall be discarded from the top of the ingot to insure sound rails." Under that agreement the buyers of rails can get, and do get, perfectly sound steel. The interruption of the term "sound" in this case means entirely free from piping or spongy metal.

Sound steel rails of standard composition are perfectly safe to use, and when the railroad companies have exercised their rights given by the specifications in their inspection at the mills, while rails are being made, and thereby obtained sound rails, they have done their whole duty toward themselves and their patrons, whose safety and welfare they are bound to protect.

But the question arises why do the railroad people, or so many of them, come up with a demand for more discard, in some instances asking for a fixed amount not less than 25% of the whole ingot. It is not a question of safety, but one of service. Under present specifications, the rail mills must deliver to the railroads safe rails, that is to say, free from the danger that comes from piping. They are obtained by shearing from the top of the ingot sufficient material to insure sound steel.

Then what would the railroads gain by doubling the discard if 25% should amount to that increase? They might get a larger percentage of better wearing rails than they now receive, but the gain would be purely in an economical sense, and not in one of safety. Therefore, the question of more discard after enough has been made to insure sound and safe rails is purely a commercial one, and can be disposed of between the railroads and the steel companies without giving cause for any anxiety on part of the traveling public.

In addition to the discard sheared off the bloom, a crop end is cut off the long rail when it is finished, taken from the end toward the top of the ingot. This is about 6 ft. long and is used for a drop test. One such test piece is taken from every blow of steel. It is placed on steel wedge-shaped bearings, 3 to 4 ft. apart, and struck with a 2,000-lb. weight, falling 15 ft. to 22 ft. (depending on size of rail tested). Deflection of test piece under this drop is carefully noted and made a part of the inspection records. If the test piece breaks under the drop, all rails from the blow represented by that test must be discarded.

This is the most satisfactory proof of the quality and strength of the rails that can be made. If the steel is brittle, it will be discovered by the character of the break. If piped, that condition can be seen in the fracture and will determine at once whether or not sufficient discard has been made at the shears to insure sound steel. If the metal is very soft, it will show by excessive deflection. It can be seen, therefore, that the drop test furnishes many safeguards against passing defective or inferior material.

Another difficult part in the making of steel rails is in the section. In the first place, it has to be very accurate. The section is continually checked during the process of rolling. This is done by a steel template of half the rail. The rail section is tested on both sides by the same template, and therefore each half is as nearly like the other as possible to make it. In checking rail sections, the inspector has to guard against either over or under size and always strives to maintain perfect symmetry. In this detail, differences of $\frac{1}{64}$-in. cannot be ignored and the wonder is how such ponderous and coarse machinery as constitutes a rolling mill can be so nicely adjusted as to accomplish such fine results. It is not easily done, and it should be remembered that the turning or shaping of rolls and the manipulation of steel through them when rolling is under way, is the most intricate part of the rail-making process.

It is of interest to note how closely in shape the T-rails used at the present time are to those first made for use in this country.

In the year 1830, Robert L. Stevens, President and Chief Engineer of the Camden & Amboy R. R., received orders to visit England to inspect and report upon railroad matters there; and was directed to purchase all-iron rails.

It was during this voyage that Mr. Stevens designed the first rail ever rolled with a base. He whittled several model sections out of wood, which he obtained from the ship's carpenter. The shape finally taken was in general outline similar to present rail, having a head about 2 ins. wide, a base 3 ins. wide, and height 3½ ins. Rails of this general type of various weights were made for the next 30 years or more. After the Civil War, when practically all the railroads then in existence had to be rebuilt and new ones became necessary, the T-rail section was improved in detail, and in 1874 sections were brought out almost identical with many still in use. During the next fifteen years rail sections in great varieties of dimensions were produced. Nearly every railroad had its own design, and it is stated that one rolling mill during this period had to provide rolls for 119 different rail sections.

The inconvenience and heavy cost to both manufacturer and users of rails in having so many different sections led up to an effort toward adopting a series of standard shapes. This task was undertaken some time in 1888 or 1889 by a committee appointed by the American Society of Civil Engineers. The work met with a good deal of interference; but the committee persevered, and in course of three or four years brought out what is now known as the Am. Soc. C. E. sections, which give a series of shapes varying by 5 lbs. per yd. from 50 lbs. to 100 lbs.

Notwithstanding the fact that some engineers have always criticised these sections, and many roads would never accept them for use, still the widespread advantage to be gained in having standard shapes led to their rapid adoption, and within ten years from the time they were introduced fully 70% of all the rails rolled for American railroads were made of these sections. At the present time, the proportion has increased to over 75%.

One of the leading advantages to the manufacturer in the Am. Soc. C. E. sections is in the distribution of metal in its different members.

In the head there is	42%
In the web	21%
In the base	37%
	100%

There is but 5% difference between head and base, and these being so much closer than many of the sections the mills were formerly required to make, they gave the Am. Soc. C. E. sections a cordial welcome and have always tried to further their use.

At the time these patterns were designed and introduced, an 80-lb. rail was regarded as a heavy section, and some engineers even doubted whether one so heavy could be used economically. The designers, however, evidently expected railroad track to grow, for they provided for 5 lbs. per yard increase in weight till 100 lbs.

was reached, and then designed a 110-lb. pattern, apparently for good measure.

The period during which the 80-lb. rail was regarded as heavy was not of long duration, for the railways soon adopted 85-lb. and 90-lb. sections and during the past few years a very considerable tonnage of 100-lb. rails have been made.

The 90-lb. rail was an increase of about 12½%, and the 100-lb. about 25% over the 80-lb. The users of rails naturally looked for a proportionate gain in wear for the additional steel bought. But this did not always obtain and led to the criticism that they were not properly worked; that they were rolled too fast and finished too hot. An effort was then made to incorporate in standard specifications what was called a "shrinkage clause.". By this is meant that the rails when they reach the hot saw shall be at such reduced temperature that only a certain number of inches and fractions of an inch shall be allowed for the rail to contract in length from the temperature at the sawing down to 70°. It was expected that if the mills could comply with this, the steel would come through the finishing passes at a lower temperature, and the colder rolled steel would give better wear.

It was perfectly reasonable to look for those results from such conditions; but the difficulty of incorporating a shrinkage clause in general specifications and making it operative was found in the fact that rails cannot be brought to the hot saws at the same temperature in every mill. There are no two mills in which the shrinkage could be kept exactly alike, therefore, any fixed allowance in a general specification could not be made applicable in all places. The opposition to a definite shrinkage clause in specifications is raised on account of the insurmountable difficulties encountered in attempting to fix a temperature at which the finishing work shall be done in unbalanced sections. As already stated, the Am. Soc. C. E. section, or any other T-rail thus far made, has greater percentage of metal in the head than in the base. The base is not only smaller, but thinner, besides having a greater radiating surface. It can, therefore, be readily understood why there is considerable difference in temperature between head and base, when the rail goes through the finishing passes. The object of a shrinkage clause was to improve the rail head by finishing at a lower temperature, but in an unbalanced section the base is likely to get too cold to work, or so hard as to cause danger of breaking the rolls, while the head may still be hot enough to admit of some reductions. The impossibility of obtaining all that might be desirable from colder rolling in such shapes is quite apparent.

Cambering of the rails is made necessary to counteract the warping that takes place in cooling. The warping is due mainly to the shape of the section, and the rail is rarely perfectly straight when cold. Whatever warp or crook that may be left in must be taken out by cold straightening. This is done in a press under a slow-motion plunger by applying pressure on the rail centrally between bearings 42 ins. apart. The arrangement of this press has lately become part of a general specification, and for that reason should receive some notice in this connection.

It is pretty generally conceded by both rail makers and users that the strain and torture that rails have to endure in cold straightening are the most objectionable work in the whole manufacturing and finishing process. The impossibility of taking a bend or kink out of a rail without straining it beyond its elastic limit makes it necessary to set up internal stresses in the steel unavoidable. To what extent these may be harmful to the rail after it is put into service cannot be definitely determined, but it is only reasonable to infer that they have some effect.

When a rail goes into track it is placed on a series of wooden bearings, usually about 22 ins. c. to c., and fastened at the end to adjoining rails laid in the same way. The wooden bearings rest on broken stone or gravel, and these in turn are carried on the natural earth of the railroad bank or cut, as the case may be, consisting of any grade material from light dry sand to heavy wet clay, and may be solid or unstable, depending on drainage and other local conditions. Thus we see that a railroad track is constructed somewhat in reverse order from other structures built to carry loads. That is to say, the steel rail, the strongest and most permanent member of the construction is at the top, while the soft earth or wet clay, the least stable part, is at the bottom.

The rail in service has been compared to a girder, but a bridge girder rests on fixed and permanent foundations, while a rail rests on a series of varying foundations, no two of which are exactly alike at any time, and always subject to differences effected by changes in seasons and climates.

It is not an uncommon occurrence for a panel of rails in first-class track to carry a load upward of 200 tons over its entire length in half a second of time or less. During this short space of time every foot of the rail throughout its entire section is subjected to alternating tension, compression and torsion and the head to crushing and abrasion. There is not a piece of steel made for any structure whatever that has to withstand such severe treatment as that imposed on a rail. Think for a moment what a rail is expected to do. It must be hard enough to withstand abrasion, elastic enough to spring without bending, ductile to stretch without breaking, and rigid enough to carry a load with little deflection. In attempting to obtain all these qualities in a single composition, and afterward subjecting the material to the extraordinary impacts and strains that a rail receives in track, it is little wonder that some of them fail. It is rather more surprising that the number of failures is not greater.

The users contend that rails fail because of defective material or shortcomings on part of the manufacturers in the process of making. The manufacturers claim that the users do not specify the grade of steel, nor weight of rail best suited to their various traffic and climatic conditions; that maintenance of way is not always what it should be; that bad order rolling stock and irregular operation of motive power is responsible for a greater part of rail destruction. It is not posible to determine which party is most at fault, but a better understanding of failures will show that neither is wholly exempt.

There are nine or ten classifications of rail failures, but more than 95% can be placed under less than half that number. The remainder are of rare occurrence and little account.

First are the head failures which are result of piping, or caused by the metal actually shearing off at the sides, usually about on line with one side of the web. Piping, as already stated, is a defect inherent in the steel, and the whole responsibility for this rests with the manufacturer. Every practicable precaution is constantly exercised against such material going into rails, but in spite of all that can be done, some with this defect get into use.

To reconcile the fact that piped rails are found with the claim made that sufficient material is discarded from top of ingot to insure sound steel, it will be necessary to explain that piping in ingots is not confined entirely to the top, but does at times occur all the way down through the center, although it may not be continuous. Such piping will not show at the ends nor give any surface indication of its existence when rails are finished. It ordinarily develops under traffic and then appears by the head flattening or spreading out. Only a very small percentage of piped rails give out suddenly, or without first showing this condition on the head surface and affording time for removal before harm is done. Some railroad engineers pretend to say that they do not regard rails showing slight piping as particularly dangerous, and often allow them to remain in use after their condition is known. It is the opinion of the writer, however, that rails which show piping in any degree are wholly unfit for any main line track, and never should be allowed to remain in service.

Split head failures occur mainly on high curvature track and on the inside or low rail of the curves. These are apparently due to irregular bearings of worn wheels and cross strains in the rail head due to the pressure of false flanges on the extreme outside corner. This brings the maximum stress at top of the rail heads, about on line with the side of web, where such breaks are generally found.

Another type of failures resulting from rail and track conditions, similar to that just mentioned, is in the metal flowing or crushing off the corners of the head. The inside wheel of a train passing around a curve, not only rolls but slips over the rail, and when the track gage is wide, it slides across the head, causing the metal to flow or shell off in long, ragged strips. This kind of failure often causes considerable anxiety among railroad engineers, on account of the seeming weakness. Such rails have an extremely bad appearance and ordinarily show excessive wear, but they are not unsafe to run over and may be retained in service without any unusual risk until completely worn out.

By far the greatest number of failed rails are due to complete fracture of the entire section. These are not only the most numerous, but the most dangerous of any in the whole classification.

There are three distinctive breaks that may be described and in a measure accounted for as follows:

First: The square break in which the fracture is almost at right angle with the axes of the rail and is often quite as regular as a saw cut. The fractured surface may be fine, close, homogeneous texture, but the shape of the break indicates excessive hardening properties in the metal, bringing it close to the point of brittleness—hence, easily ruptured by shock and therefore poor quality steel for rails.

Second: The angular, or shearing break, which generally passes through the section at an angle of 45° or less, with longitudinal axes. This shows that the rail stood a deflection and elongated before breaking, indicating ductility and a perfectly good grade of steel, and that the rail was probably broken by severe shock or excessive overloading.

Third: The base break. There are more failed rails from breaks of this character than from any other cause. It is found in varying degrees on all railroads and in rails from all mills.

The principal peculiarity of this break is that it at the center of the rail base, directly under the we develops longitudinally, extending from 6 ins. to and will then run out to the edge of the flange, re in a "half moon," or flange break, and in many also extending upward through the rail, causing plete fracture of the entire section. It is safe to sa in more than 90% of rails reported by the rail simply broken, the failures originate, as above desc in the base, and more than 99% of such breaks occ ties.

The ordinary T-rail has long been studied, with idea that it should be considered as a girder rea across short spans supported at the ends and loade the center. As a girder the rail seems to be theoreti and practically correct in shape. But it has already shown that the roadbed and ties, which constitute the foundation, are unstable and yielding and that the soli of tie bearings are at times widely variable, making bearing surface of the whole rail base quite irregu and uneven. These conditions are generally wo when the roadbed is frozen.

In consequence, the base member of the rail sect has to sustain excessive compressive strains at the high or more solid points of its bearings. The rail base compression will, on account of its shape, buckle, draw the edges of the flanges upward, thereby causing a cro strain with maximum tension at the center directly und the web, and this is the point where base break begi Therefore, it appears that the base member of the T-rail girder as now made is deficient when subjected to com pressive strain and for that reason fails.

Just at the present time we seem to have reached one of the transition periods in the manufacture and use of steel rails, in which the rails as made do not quite balance with the railroad traffic as it exists.

The manufacturer is under certain limitations in character of raw materials that prevent him from doing all that might be desirable in changes of composition of steel.

The railroads cannot recede in the matter of heavy loads and fast trains, and must by some means get rails that will give service under present conditions.

It is believed that a remedy can be obtained by the cooperation of the manufacturers and railroads in bringing out a revised rail section.

It is suggested that, in comparison with the Am. Soc. C. E. sections, both head and base shall be reinforced, and that the distribution of metal be nearly balanced, making that in the base equal to or slightly greater than in the head. It is also proposed that width of base shall be less than the height of rail, which will admit forming thicker flanges.

The advantages of a balanced section, with comparatively thick base are:

First: Lower temperature of the whole section at the final pass—hence a colder finish of the rail head, giving denser and better wearing material.

Second: Less cambering and better hot straightening, reducing, as much as possible, the objectionable cold straightening work.

Third: A reinforced head to provide against splits and other head failures.

Fourth: A reinforced base to overcome the weakness that seems so prominent in present pattern rails.

It is expected, also, that with this pattern rail the higher carbon steel from grades of ores now available may be made with safety, and by longer service prove a benefit to the railroads.

A SHORT METHOD OF RECOMPUTING SEWER DISCHARGES FOR A CHANGED VALUE OF n IN KUTTER'S FORMULA.

By G. S. COLEMAN,* Assoc. M. Inst. C. E.

About a year ago the writer had occasion to make an elaborate series of calculations for a new sewerage scheme which, amongst other things, involved the estimation of the discharging capacities of several existing sewers in various states of decay. He was instructed to base his work upon Kutter's formula and was given a number of tables of discharges based thereon and calculated for a "coefficient of roughness" of 0.012. The instructions also specified various coefficients of roughness to be adopted under various conditions. The writer was therefore confronted with the problem of either recalculating some thousands of discharges or judging some way of converting the given values to the corresponding values for the altered coefficient. After a good deal of thought he evolved the following method and offers it with the greater confidence, since the comparative table given below shows limits of error very small in comparison with the probable accuracy of the formula.

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Kutter's formula, as usually enunciated in English and American text-books, is as follows:

$$v = \frac{a + \frac{l}{n} + \frac{m}{s}}{1 + \left(a + \frac{m}{s}\right)\frac{n}{\sqrt{R}}} \times \sqrt{RS}.$$

where v = velocity of fluid in feet per sec.
s = line of angle of slope.
R = hydraulic mean depth of flow.
n = coefficient of roughness, its value depending on the state of the culvert or pipe, and usually varying in sewerage work from 0.010 to 0.017.

l, m, a are constants having, in English measure, the values of 1.811, 0.00281 and 41.6.

The value of v can be written thus:

$$v = \frac{\frac{l}{n} + \left(a + \frac{m}{s}\right)}{\sqrt{R} + \left(a + \frac{m}{s}\right)n} R\sqrt{S}$$

and for any particular value of s the expression $a + \frac{m}{s}$ becomes a constant and can be calculated beforehand. This and the values for $\frac{l}{n}$ have been worked out by Colonel Moore in his "Sanitary Engineering," and the tables have been of immense value to the writer in preparing the original work here referred to.

Suppose for the moment that s is constant:

$$\text{Then } v \propto \frac{\frac{l}{n} + \left(a + \frac{m}{s}\right) . R}{\sqrt{R} + \left(a + \frac{m}{s}\right)n}$$

If v_1, v_2 be successive values of v corresponding to values n_1 and n_2 of n,

$$\text{Then, } \frac{v_1}{v_2} = \frac{\left\{\frac{l}{n_1} + \left(a + \frac{m}{s}\right)\right\} R \quad \sqrt{R} + \left(a + \frac{m}{s}\right)n_2}{\sqrt{R} + \left(a + \frac{m}{s}\right)n_1} \times \frac{}{\left\{\frac{l}{n_2} + \left(a + \frac{m}{s}\right)\right\} R}$$

$$= \frac{\left(\frac{l}{n_1} + a + \frac{m}{s}\right)\left(\sqrt{R} + a + \frac{n}{s}\right)n_2}{\left(\sqrt{R} + a + \frac{m}{s}\right)\left(\frac{l}{n_2} + a + \frac{m}{s}\right)n_1}$$

But if s is constant the value of the expression $\left(a + \frac{m}{s}\right)$ is constant. Also $\frac{l}{n} + \left(a + \frac{m}{s}\right)$ will also have a constant value if n be constant.

Let, therefore

$$\frac{l}{n_1} + \left(a + \frac{m}{s}\right) = p \text{ and } \frac{l}{n_2} + \left(a + \frac{m}{s}\right) = q.$$

Also $\left(a + \frac{m}{s}\right)n_1$ and $\left(a + \frac{m}{s}\right)n_2$ will have fixed values for given values of n_1 and n_2. Let them m be r and t.

$$\therefore \frac{v_1}{v_2} = \frac{p}{q} \times \frac{\sqrt{R} + t}{\sqrt{R} + r}$$

But $\frac{p}{q}$ will now be constant and $= x$, say

$$\therefore \frac{v_1}{v_2} = \frac{x\,(\sqrt{R} + t)}{\sqrt{R} + r}$$

Again, $\frac{v_1}{v_2} = \frac{Q_1}{Q_2}$ where Q_1 and Q_2 are the discharges corresponding to v_1 and v_2, since the conduits are supposed to always run full or at the same depth. The values of $\sqrt{R}$, t and r are easily found, and the final result can then be solved by logarithms.

The writer therefore proceeded to obtain these values for circular sewers from 4 ins. diameter to 10 ft. in diameter, and for standard egg-shaped sewers from $2\frac{1}{2} \times 1\frac{2}{3}$ to 6×4 ft. As the gradients were assumed constant any value might, theoretically, have been taken, but 1 in 2,000 was ultimately chosen for the former and 1 in 1,000 for the latter, it being found that a slightly greater degree of accuracy was obtained by using comparatively flat gradients. The range for n was taken from .010 to .017, it being considered that this represented the probable extremes in sewerage work.

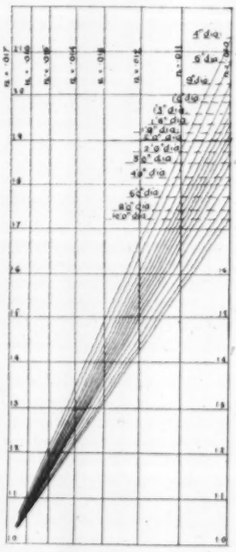

Diagram for Recomputing Sewer Discharges with Changed Values of n in Kutter's Formula.

It then became necessary to obtain an easy method, if possible, for finding the multipliers for intermediate values of the roughness, and the accompanying diagram was finally adopted. The verticals giving the dimensions of the multipliers were first calculated for their positions on the 10-ft. diameter line and by completing, as shown in the sketch, the same verticals were made to suit the other sizes of sewers, since the triangles formed with the horizontals are proportional.

A similar diagram was made for the egg-shaped sewers, only in the actual work the sewers increased in size by 3 ins., and the whole were drawn so as to read to four decimal places.

It then became necessary to compare results as found by the diagrams with those actually calculated. The accompanying table shows a few results, taken from the actual work of the sewerage scheme referred to and not specially selected in any way. It will be noted that widely different sizes and gradients have been used, and that the error never exceeds 0.4%, a degree of accuracy never claimed for the original formula by its inventors.

It will be observed that the error assumed in the beginning of this article—the constancy of s—makes practically no difference in the result, besides lessening the labors of calculation enormously. The error, so-called, would probably be still less if the diagram had been drawn to an even larger scale, and appears to be limited by the "personal equation" of the draftsman and the operator.

CONVERSION RESULTS FOR CHANGED VALUES OF n, AS DETERMINED GRAPHICALLY AND BY COMPUTATION.

Size of sewer.	Gradient, 1 in	Conversion from n =	to n =	Calculated values in cu. ft. per min.		Values by diagram.	Error, %
12" diameter	750	0.017	0.012	51.676	81.72	81.90	0.22
8' 0" diameter	500	0.017	0.015	18,790	21,449	21,449	nil
3' 0" × 2' 0"	100	0.017	0.015	1,596	1,809	1,801.7	0.32
3' 0" × 2' 0"	500	0.016	0.011	768.5	1,199.4	1,201.2	0.16
5' 0" × 3' 4"	500	0.016	0 011	3,089.8	4,713.4	4,697.8	0.31
5' 0" × 3' 4"	100	0.017	0.011	6,475	10,582	10,582	nil
5' 0" × 3' 4"	1,500	0.016	0.011	1,769	2,704	2,696	0.25

In conclusion it may be added that a pair of these diagrams is proposed to be included in a forthcoming set of tables to be published by the writer's department.

ANNUAL CONVENTION OF THE ROADMASTERS' AND MAINTENANCE-OF-WAY ASSOCIATION.

The 25th annual meeting was held at the Sherman House, Chicago, on Nov. 12, 13 and 14, with the President, Mr. C. H. Cornell (C. & N. W. Ry.) in the chair. About 60 members were registered. After the formal opening proceedings about 10:30 a. m. on Nov. 12, the meeting entered directly upon the business of the convention.

SHIMMING TRACK.

The President started the proceedings with a short paper on "How to Maintain Tracks and Keep it in Line and Surface During Winter Months." This related entirely to experience and practice in the shimming of rails upon the ties in order to avoid the abrupt changes in level or surface due to heaving of the ground by frost. He remarked that shimming is but a makeshift way of dealing with conditions which should not be allowed to exist, and the proper remedy for which is drainage. The discussion showed that drainage of the heaving ground, or the removal of this ground to a depth of 2 ft. to 3 ft. and the laying of broken stone, gravel or cinders in its place, were regarded as the proper remedies.

The discussion turned largely, however, upon individual practice in certain severe cases, in one of which the use of two ties on the original tie was necessary to bring the rail up to the required level. This was the experience of Mr. Horton in a cut on the Pere Marquette Ry. Tile drainage and gravel ballast proved ineffectual; finally, 3-ft. ditches were put through the cut, the gravel was removed, and cinders were applied again and again until they reached bottom and the clay no longer worked up through them. He makes all shims, no matter how thin, the full length of the ties, so as to carry both rails. Shoulder tie-plates are used on high shims.

Mr. Jones (C., B. & Q. Ry.) uses sawed shims for all thicknesses of ⅛-in. and upward; they are bored for the spikes. It was remarked that on the Erie Ry. no shimming over ½-in. is allowed, and a few members thought there was little need of shimming on main lines. On the other hand, the almost universal opinion was that shimming is required more or less on nearly every road; if not on main track, it will be required for the lighter track construction of branches, sidings and yards.

DESTROYING VEGETATION ON TRACK.

This very brief paper by Mr. J. W. Guffy (A. T. & S. F. Ry.) simply gave his own experience on a division having earth or dirt ballast, with a heavy growth of grass and weeds. He has this cut with light steel shovels every six weeks for about six months. It is only cut between the ties outside of the rails, and as far inside as can be reached with a shovel slipped under the rail. This costs $7.50 per mile each time. In October, the grass is cut clean both inside and outside the rails at a cost of about $12.50 per mile. The three light cuttings and the final complete cutting cost together about $35 per mile per year. The paper mentioned weed-burners unfavorably, although the author admitted he had had no experience with them. Mr. W. M. Camp pointed out that weed-burning machines using oil and gasoline are in use on a number of roads, while the Oregon Short Line is using a brine-spraying machine to kill weeds. The cost for oil and labor is from $1 to $2.50 per mile. The machines are run at speeds of about 3½ to 4 miles per hour. It was also pointed out that on branch lines with small section gangs, it is almost impossible for the men to keep the vegetation under control. Mr. C. E. Jones (C. B. & Q. Ry.) stated that on some lines the cost of clearing track from grass and weeds by hand amounts to $50 per mile per year, but this includes cutting the sod to a grass line 11½ ft. from the center of the track.

RAILWAY WRECKING TRAINS.

This was the best committee report presented, and was the work of a committee composed of C. Buhrer, W. H. Kofmehl, A. Boydston and B.

A. West. An abstract of this is given below, with some changes as made during the discussion.

The wrecking crews should be composed of men employed in the mechanical and car departments, as they are better able to handle derailed and wrecked engines and cars than other classes of employees. The wrecking crews when on the road and at wrecks (and in the absence of the superintendent) should be under the authority of the roadmaster of the division. Cooperation of the employees and heads of different departments is needed to facilitate clearing the wreck and repairing the damaged track, in order to reopen the road for traffic as quickly as conditions will permit.

At each division headquarters on busy trunk lines a wrecking outfit and crew should be located. Such outfit should consist of a 50, 75 or 100-ton steam wrecking derrick; one tool car to contain all necessary tools and blockings; one car for track material; one car for extra trucks, and one commissary car supplied with a cook stove. The wrecking outfit should be in charge of a wrecking master and ten competent car repairers. The steam derrick should be in charge of an engineman and fireman. A reliable man should also be stationed on the steam derrick to take the orders and signals from the wrecking master, and give them to the engineman.

The wrecking outfit should be placed at division headquarters on a special track that at no time will be blocked, but that can be approached at all times quickly with an engine.

The wrecking foreman and the men should be employed in the car department. The engineman and fireman for the derrick should be employed either at the engine-house or machine shop, in order that they can be called on short notice. At all times the wrecking crew should be called by telephone, electric bells and swift callers. The wrecking train should be taken to a wreck by the first engine and train crew available.

For lighting operations at night, the Davis acetylene light attached to the derrick boom seems to be the best. The Wells light, the Buckeye light, torches and Dietz lanterns will also supply good light. For emergency use, a supply of canned goods and coffee should be kept in the commissary car, so that in serious wrecks the wrecking force can be supplied with lunch, until such time as the men can be conveniently spared to go to hotels for meals. If hotels or eating houses are far apart, meals should be provided in the commissary car.

The head of the track department and the section foreman of the division on which the wreck occurs should be advised by the train dispatcher as promptly as possible of the nature of the wreck as reported to him, so that they can order out whatever track men may be needed to take care of the damaged track and to assist the wrecking crew.

The wrecking outfit should be provided with a good supply of pine and oak blocking from 1-in. plank to 2, 3 and 6-in. and from 24 to 36 ins. long, and a supply of wooden wedges of different sizes. Four to six 20 to 50-ton jacks should be kept in the tool car. However, with a 75 to 100-ton steam wrecking derrick, jacks are not needed or used much, the derrick doing the work much quicker.

Four ¾-in., 15-ft. truck chains with a grab hook at each end and a ring in the center should be kept in the tool car. Two large and two small grab hooks to be used to turn over car frames and car bodies are needed in connection with the derrick. With them a box-car body can be rolled over very quickly to clear obstructed tracks. At least 20 chains from ⅝-in., ¾-in., ⅞-in. and 1 in., 15 ft. long, should be provided for use in chaining trucks to body of cars and lifting them and chaining cars together, where draft rigging and couplers are broken. In addition to these, there should be at least six 1¼-in. chains 20 ft. long, for heavy lifts. There should be four 2-in. wire cables 20 ft. long, to roll and lift cars and engines. Also at least four hemp ropes from 1 to 3 ins. diameter and 200 to 300 ft. long, with the proper snatch blocks. There should be two guy anchors, four wrecking frogs, a good supply of tools (such as sledges, chisels, hammers, wrenches) to disconnect bent and twisted rods. There should also be a full set of track tools, such as claw bars, lining bars, spike mauls, track wrenches, track chisels, shovels, picks with handles, and track gages for emergency cases. Also scoop shovels and baskets and bags to handle and transfer grain.

The car with track material should be supplied with 20 rails and fastenings for same (of the pattern used on main line), one switch complete, one right-hand and one left-hand main-track spring frog, two guard rails, 100 to 150 ties, 5 kegs of spikes and 2 kegs of bolts.

The first aim should be to clear the track and reopen it for traffic. After traffic is moving the wreck should be picked up, cars unfit for future use burned and scrap picked up as soon as possible. Damaged freight should be reloaded and turned over to the claim department for adjustment. Where a large amount of freight has been damaged or stock killed or injured, the claim department should be advised, so that it can have an agent on hand.

In all wrecks the first aim should be to take care of injured persons. Farmers often give valuable assistance by taking care of injured persons until medical assistance can reach them. Medical assistance should be called from the nearest villages and cities near which the wreck occurs, and every possible effort should be made to get the most available physicians to the wreck as quickly as possible. The wrecking outfit should also be supplied with two or more stretchers and blankets to carry injured persons.

In the discussion of this report the question of the proper officer to assume direct charge of the operations was discussed at some length. The report as presented mentioned the superintendent, but it was pointed out that while he is the head official of the division he is not likely to attend wrecks with the object of directing the work. The general opinion was that the roadmaster should be in supreme charge of wrecking operations, having under him the wrecking crew of mechanics and car repair men and also the section men. The plan of calling the wrecking crew by the shop whistle was considered bad practice; it not only advertises the fact of a wreck, but alarms the families of employees, so that the offices are swamped with anxious callers and telephone messages. There was also a general opinion in favor of providing meals in a commissary car attached to the wrecking train, rather than rely on eating houses and hotels. The meals are better, the men are better cared for, there is less time lost, and the arrangement is more convenient in many ways.

COST OF BALLASTING OLD TRACK AND RENEWING TIES.

The committee presented figures from different roads, but these were not classified on a uniform basis. We have tabulated the figures, herewith, as a matter of interest. The report also briefly noted the cost of renewing ties. On the Chicago & Northwestern Ry., with an average of 425 ties renewed per mile (evenly distributed) the cost is 16 1-7 cts. per tie. This is where track is in such condition that resurfacing is not necessary. The old ties have to be dug out of the roadbed, the new ties inserted and tamped, the roadbed dressed, and old ties gathered up and neatly piled. On the Lake Shore and Michigan Southern Ry. the cost is 13.8 cts. in gravel ballast. On the Atchison, Topeka & Santa Fe Ry., where the track is up to grade and cannot be raised, it costs about 25 cts. to renew each tie. Where the track has to be surfaced, the cost will be only 8.3 cts.

COST OF BALLASTING EXISTING TRACKS,
(Cts. per cu. yd.)

Railway	C. & N. W.	L. S. & M. S.	A. T. & S. F.	
Ballast	gravel[1]	gravel[2]	stone[3]	stone[4]
Ballast, loaded on cars	7	18	53½	61½
Hauling (50 miles)	..	7	..	5½
Hauling and unloading	10⅔	..	..	..
Digging out old ballast	..	15	15	..
Unloading & placing in track	..	15	..	33
Placing in track	12⅓	..	..	..
Hauling, unloading and placing in track	..	..	40	..
Total	30	55	108½	100

[1]Pit gravel, 3,400 cu. yds. per mile; plowed from flat cars. [2]Washed gravel, first cost includes washing; Rodger ballast cars. [3]Stone ¾-in. to 1½ ins.; Rodger ballast cars. [4]Crushed stone, 3,400 cu. yds. per mile; Rodger ballast cars.

A paper on "Track Work as Skilled Labor" was read by Mr. W. M. Camp, and showed the important character of the work now frequently entrusted to unskilled labor of very poor quality. The fitting up of joints, and the putting in of switch and curve work cannot be properly or economically handled by the class of labor now generally employed. A paper on "The Oiling of Roadbed," by Mr. J. C. Rockhold (A. T. & S. F. Ry.) was read by the Secretary in the absence of the author.

RELAYING RAILS.

This was a one-man report, written by the chairman of a committee, and some members of the committee objected to its style, as they had not been consulted and had not seen the report till it was read at the meeting. An abstract is given herewith:

All rails to be laid one at a time, except in a yard where business is too heavy to permit the use of the tracks. The men in the rail-laying gang must be organized so that each man knows his own work.

Adzing should be done in advance of rail laying as far as possible, as this is the heavy item of rail laying on nearly all roads. All ties to be plugged where spikes are pulled, and adzed to an even bearing for the new rail. A push car should be kept in front of the rail gang to carry joints and necessary tools for closing up quickly.

A good rail gang will be composed of 50 or more men, including one general foreman, two assistant foremen and a timekeeper. The men to be distributed as required by the work, weight of rail, etc. The train dispatcher should be notified each evening before what points work is to be done the next day. On a busy road a telegraph operator should be with the rail-laying crew to keep the foreman posted as to the trains.

All rails to be full-bolted the day they are laid. The rail should be gaged as soon as it is laid, and then spiked. Any joint ties that are low should be at once shimmed or tamped up. The unloading of rails should be done with great care, so as not to bend any rail. All rails should be unloaded as nearly in place as possible. Thermometers and steel expansion shims to be used.

A switch point can be used to close up temporarily for the passage of trains, but the foreman must use great care and see that his stock rail is on a level with the switch point, as a serious derailment may be caused by an engine trailing through the switch point. At night the rail should be cut, closed up and full-bolted for the passage of trains at regular speed.

Where rails of different sizes are being used, compromise joints or tapered rails must in all cases be used for the safe passage of trains. Nut locks should be used on all rails, as without them the bolts that are now furnished cannot be kept tight.

The discussion on this report was animated and protracted. Mr. Camp suggested that some roads lay rails in strings already bolted up, but this practice was not regarded with favor by the members. The difficulties of getting the ties properly adzed and trimmed by the average section men was brought out; they will cut soft ties recklessly, but skip hard or knotty ties. One speaker employs a "handy man" specially for this work. There was some discussion as to whether rails should be given an inward cant. Some of the tie-plates are now made to give this, and one roadmaster of the Atchison, Topeka & Santa Fe Ry. trims the rail seats of the ties for the same purpose; the cant is increased for the high rail on curves, as it holds the gage better. This road also uses a portable telephone equipment, hooking over the wires, to enable the foreman of a relaying gang to keep in touch with the operators at the stations on either side of his work. Other roads put a temporary operator with the gang, if the traffic is heavy. One speaker said that on his road all trains are required to come to a full stop at the flagman, and proceed slowly past the work. This was objected to as being unnecessary, while it is liable to cause trouble and delays from the parting of heavy trains that are stopped in this way. As to the cost of the work, it was shown that this must vary in each case with the character of the track, the organization, and the traffic. On a branch line with light rail and one train per day it had been done for $74 per mile. With heavy rails and traffic it might run up to $200 (or more) per mile. As to the closing up of the work to let trains pass, the general practice is to use a switch rail by day, and to put in a regular bolted joint at night. Some thought the switch rail safe for both day and night work. Others use short pieces of rail, which are carried on the push car with the gang, and used as required. Where switch rails are used, they should never be opposite each other. In connecting up new heavy rail with old light rail, various forms of compromise joints are used, but some roads use a tapered rail 12 ft. long, planed and forged so that it changes gradually from the one section to the other. This was invented some years ago by the late Mr. Curtis, Engineer of Maintenance of Way of the Southern Pacific Ry.

There was an extensive exhibit of track materials, tools and appliances, and one morning was largely occupied by five-minute talks from the representatives of the several exhibitors.

The election of officers resulted as follows: President, J. A. Kerwin (Missouri Pacific Ry.); Vice-Presidents, A. E. Hansen (C. & N. W. Ry.) and W. A. Brandt (C. & N. W. Ry.); Secretary, W. E. Emery, Engineer of Maintenance of Way, Chicago & Alton Ry., Kansas City, Mo. The next meeting will be held at Milwaukee, Wis., in November, 1908.

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In another part of this issue is shown the design of a new type of street cars and the tentative scheme of operation on a portion of the New York City surface lines. A few other cities are about to undertake similar trials and upon the success or failure of these initial installations, much depends. Probably at first these cars may be criticized by the public, but it is to be hoped that they may continue to run until travelers become familiar with them.

There are several reasons why these new cars may be expected to better the street railway service on crowded lines. One of the chief of these is the provision for simultaneous exit and entrance by separate passages. This feature alone should greatly reduce the time lost in stops and thus increase the speed of cars. While this benefits the street railway companies, it is of even more importance to the traveling public.

The fact is that on a large percentage of American street railways the traffic capacity—measured in passenger miles per hour—is actually cut down during the rush hours by the slow rate at which cars are moved.

It is impossible to make short stops where a half dozen passengers waiting to board the car are standing in the way of a half a dozen others who get off. These delays at stopping points, moreover, inevitably tend to bunch the cars. As soon as a car falls a little behind the one ahead, a large crowd awaits it at each street corner, and the length of stops increases rapidly as the passengers struggle in and out of the narrow single exit. Meanwhile the cars behind close up on the delayed car, and the running time of a string of four to six cars is often limited by the slow process of loading and unloading the car at the head.

American street railway managers have so long and so blindly followed the principle that "it is the strap-holders that pay the dividends" (on the water!) that they have allowed their service to become criminally deficient and have also lost a vast amount of revenue through uncollected fares. A car which can take on and discharge passengers promptly and on which every passenger will pay his fare on entering can save a great amount to the operating companies as well as render improved service to the travelers.

Of course, the benefit of the improvement can be largely neutralized where too few cars are furnished; and it is very necessary that the street railway companies should adopt a ticket system, selling tickets in quantity at a slight reduction from the regular fare and thus educate the public to the ticket habit instead of the nickel habit. We believe that the custom of paying street car fares in cash is a survival of horse railway days. If the pay-as-you-enter car brings about the substitution of the ticket system, it will save to the street railways hundreds of thousands of dollars now lost through fares uncollected and fares not turned in by conductors.

An engineering-contract investigation of world-wide interest is now in progress in New York City. The primary question involved is whether a public body, with discretionary power, is ever justified in awarding a contract to other than the lowest bidder. Point is given to the question by a difference of $2,350,000 between the lowest and the next to the lowest bid, and by the facts that the construction of the immense dam at issue will extend over seven years, that the dam will impound 120,000,000,000 gals. of water, and that any delay in the construction of the dam may cause incalculable damage in New York City, since such a series of dry years as has been experienced in the past, coming before the reservoir was completed, would result in a water famine. The main facts regarding this contract were stated and commented on in our issue of Sept. 5, 1907. (For a description of the Ashokan Reservoir project, see Eng. News, May 9 and Aug. 1, 1907; and for the principal quantities, see July 11, 1907, p. 47.) Notwithstanding the execution of the contract, the award was taken up for investigation by the Commissioners of Accounts, two city officials having broad powers of investigation of all matters pertaining to the expenditure of city moneys. These Commissioners referred the matter to an advisory board composed of their chief engineer and three other engineers. The advisory board having reported its unconditional disapproval of the award, the Commissioners of Accounts, with the approval of Mayor McClellan, began a more formal investigation on Nov. 18, exercising their power to summon and examine witnesses under oath. In view of the hearing now in progress, it would be unwise to make any comments that would seem to prejudge the case, but in view of the great importance and interest pertaining to the whole matter, we may repeat some of the statements of fact made in our issue of Sept. 5, and summarize the course of events since that date.

The contract involves, besides minor work, the construction of the Olive Bridge Dam, a composite masonry and earth structure requiring immense quantities of excavation and embankment. As a preliminary to the bids received last summer, the Chief Engineer of the Board of Water Supply estimated that the work would cost $12,841,000. The lowest bid, by the John Peirce Co., was $10,315,350, and the next lowest was $12,669,775, this being by the MacArthur Brothers Co. and Winston & Co. Three other bids were received, the highest being $14,707,750. The estimate of the Chief Engineer, Mr. J. Waldo Smith, M. Am. Soc. C. E., was supported by the studies of various assistants who had devoted a large amount of time to the work. The various contractors, of course, also gave much study to local conditions. One bid was about 20% below the estimate by the chief engineer, one about the same as that estimate, and three were higher. The highest bid of all was 16% above the estimate of the chief engineer, and about 30% in excess of the lowest bid. The chief engineer advised that the contract be awarded to the next to the lowest bidder, urging that the latter would lose money on the contract and that under such conditions the city was likely to suffer embarrassment and was also liable to serious delays. It was also urged that the lowest bidder was inexperienced in earthwork, on which its bid was particularly low; that the lowest bidder relied upon outsiders for its figures on this material; that the principal of the company was in Europe when the bids were made up; and that on his return, and after the bids were made public, he admitted that he would lose money if the contract was awarded to him. The opinion of the chief engineer was supported by the three consulting engineers of the Board of Water Supply, in as many independent reports, in which they answered specific questions put to them by the Board of Water Supply. The consulting engineers were Messrs. William H. Burr, Frederic P. Stearns and John R. Freeman, M.'s Am. Soc. C. E. When the Commissioners of Accounts took the matter up, they sought an opinion from their chief engineer, Mr. Otto H. Klein. On receiving his report, adverse to the award, the commissioners retained, to act with Mr. Klein as an advisory board, Lieut.-Col. Thomas W. Symons, M. Am. Soc. C. E., of Washington, D. C., and Messrs. Halbert P. Gillette, M. Am. Soc. C. E., and Daniel J. Hauer, of New York City. This board was appointed on Oct 29. On Oct. 30 and 31, it visited the site of the proposed dam, and on Nov. 6 it handed in a report unanimously against the award. The board held that the lowest bid was one that promised profit, even on the low-unit prices for earthwork. It also held that the successful bid was based on excessive figures. On the general question of awarding contracts to other than the lowest bidder, the advisory board stated that in its opinion such a practice

> is not salutary, but directly the reverse . . . . that it gives opportunity for collusion between bidders after the opening of the bids and between bidders and contracting officers, or the deception of contracting officers. It is also objectionable as discouraging competition by contractors . . .. it would result in a complete demoralization of all public works, do away with honest competition, and bring about a frightful reign of collusion and graft.

From the foregoing review the reader can see that thus far there is a division of opinion on two main points: (1) Whether it is sound policy to award a contract for public works to other than the lowest bidder, and (2) whether the John Peirce Co. was likely to lose money and the city suffer on account of the company's low bid for the Ashokan dams. On both these questions the affirmative is held by the three members of the Board of Water Supply, the Chief and Department Engineers of the board, and by its three consulting engineers. The negative is held by the two Commissioners of Accounts, their chief engineer, and their three advisory engineers. The work of constructing the dam is in progress, and as there has not been the slightest hint of collusion or fraud, either the past or future investigation of the award can have no practical bearing upon the present contract. The points at issue, however, are very important and deeply interesting, and if the Commissioners of Accounts, by an investigation of a more formal character than that yet held, can do more than pile up mountains of conflicting opinion on each side of the questions at issue, well and good; if not, their time and energy might far better be devoted to other phases of municipal administration in a city where investigation of some department or corporation is always in progress or being demanded.

The limits of achievement in engineering construction move forward in a very gradual progression. The exceptions are rare, especially in the quantitative limits, in matters of magnitude, difficulty and the like. Sudden advances made through basal inventions or dominating innovations are less rare; indeed they may almost be said to come within the range of common experience. But quantitative limits are more stubborn, and yield only gradually to the attack. Thus, speed of transportation on earth or on water has progressed in small gradual steps; only when a qualitative advance was made, as by the introduction of the steam locomotive, or the automobile, for instance, do we observe a sudden jump in the limits of what could be achieved. The exceptional cases, the instances of sudden advance without change in means or materials are rare. Such constructions as the Eads Bridge, the Eiffel Tower, the Ingalls Building, which represent a sudden large step forward into the region of the unaccomplished, an advance comparable in magnitude with the entire

extent of previous development, come before our attention only at long intervals.

A remarkable case of this kind is soon to come before us, perhaps, in the Henry Hudson Memorial Bridge, the design for which is fully described elsewhere in this issue. This design represents a serious proposal for a performance of most exceptional magnitude in a field where difficulty piles up at rapidly increasing ratio with every fresh increase of size—the field of masonry arch construction. The projectors of this bridge have no precedent. The largest masonry arch ever built is less than 300 ft. in span, and the largest concrete arch only 233 ft. Such structures are no more of a precedent for a 700-ft. arch than a 90-ft. arch is for them. Now, 90-ft. arches are commonplace, built almost daily, but masonry arches exceeding 200 ft. are attempted very rarely; the odds against the longer span are evident.

It might almost be said, from our point of view, that the Hudson Memorial Bridge design differs fundamentally from previous arch designs, in employing a large percentage of steel for the purpose of purely compressive reinforcing. As is stated in our descriptive article, no possible tension is to be apprehended, and therefore reinforcement for tensile stresses has no place. The enormous amount of steel in the arch ring is frankly used to reduce the compressive stresses in the concrete. This has not been done before in concrete arch design, we believe. Where steel has been used in concrete arches in the past, it has been for the purpose of resisting tension from live-load moment, or for ensuring monolithic action by tying the whole ring firmly together, or, in some cases, for assisting in the erection. None of these objects figured in the design of the Hudson Memorial Bridge. Had it been thought safe to use a maximum compression of 1,000 lbs. per sq. in. in the concrete, the steel would not have been required. As it was, with 750 lbs., the steel proved necessary to furnish additional strength with small increase of weight. The result is a concrete arch which contains more steel than would have been required to construct an equivalent steel arch pure and simple.

This statement, by the way, means that the design is much more costly than a steel arch for the same service. Yet the designers say that economy required the percentage of steel to be kept down as low as possible; that is to say, an increase of steel from 2% to 3% would not save enough concrete to pay for itself. But evidently an increase of steel to 100% produces a saving. The contrast implies, we might conclude, that the structure designed is inherently unsuited to the case, from a purely economical standpoint.

The difficulties of masonry arch construction lie in erection rather than in design or in cost questions. To a certain extent the same statement applies to the construction of steel bridges, no matter what their type: truss, arch or suspension. But in steelwork there is far greater opportunity for the designers to lighten the labors of the erector. In stone or concrete arch work the erection remains substantially independent of the designer's work. We must therefore regard any notable achievement in masonry arch construction as a triumph of the builder, or erector. And conversely, when a new and greater problem is proposed, it is a problem put to the builder, not to the designer. The Hudson Memorial Bridge is preeminently a problem put to the builder. In fact, with reference to the choice of span, we may say that the builder has been relieved of a relatively small difficulty (namely founding piers in deep and unsatisfactory bottom), and in its place has been saddled with the far greater difficulty of erecting the great steel and concrete arch.

On this basis we have to look upon the Hudson Memorial Bridge project as the mere statement of a problem, not as its solution. The plans elaborated by the Department of Bridges of New York City constitute an assertion that a concrete arch of the enormous dimensions proposed can be so proportioned that it will stand up and be amply safe, when once built. The stress computations carry no guarantee that the erection of the structure is feasible.

The interesting question therefore comes before the reader in an open, unprejudiced manner, whether and how the structure as designed can be constructed. Given a navigable stream some 500 ft. wide, with frequently rapid currents, with a soft mud bottom extending to 60 ft. below water level, rock at a depth of 70 to 125 ft., in which a supporting structure must be erected 700 ft. long, 70 ft. wide, capable of carrying about 2 tons per square foot of ground-plan area: how is the task to be undertaken, and how easy or difficult will it prove? We imagine that it will prove a tremendous undertaking, in founding the supporting works, in constructing the falseworks to fulfil its several purposes, and in placing the many thousand yards of arch concrete around an immense steel skeleton so as to form an unstrained monolith. The solution of the problem, that is, the actual execution of the work, will certainly be worthy of most careful attention.

FILTRATION FOR THE CROTON WATER SUPPLY, NEW YORK CITY.

It has been obvious for a number of years past that the time was rapidly approaching when American cities would adopt filtration for all their surface water supplies, as generally as have for some decades the cities of Great Britain and Germany. Recent years have shown rapid advances in the provision of filtered water in this country. Following the lead of such smaller cities as Lawrence, Mass., and Albany, N. Y., there have recently been constructed or are now being built model filtration plants for Providence, Philadelphia, Washington, Pittsburg, Cincinnati, and Louisville. New Orleans is about to begin or has already begun construction of filters. St. Louis is supplementing by coagulation the sedimentation basins in use there for many years. Omaha also has the benefit of sedimentation. Minneapolis has been on the verge of making much-needed improvement in its water supply for a decade or so. The water company at Denver, with a supply in many respects that seemed to be unquestionable, has installed and added to filters from time to time. Hundreds of smaller places have more or less efficient water purification plants, and the number is being added to every month.

It is not at all surprising to see one city after another joining the water purification ranks. The wonder is that the delay has been so long and that progress, once well begun, has not been more rapid, for the typhoid statistics of the country and the increasing pollution of the streams from which the greater proportion of the volume of municipal water supplies is drawn both point to the emphatic need for purer water. And it is not the typhoid statistics alone that indicate this need, since, although more difficult to prove, there are many reasons for believeing that polluted water supplies materially increase the general death rate and perhaps have a great uplift on the rate from diarrheal diseases.

It is a pity that the mortality statistics of the country as a whole are so scanty and so unreliable that no one tell the exact relation between impure water and typhoid fever, nor with even as much certainty the beneficial effects of pure water upon other causes of death than typhoid. If death figures in these respects are uncertain and incomplete, the statistics of cases of typhoid and other communicable diseases are far more so. But notwithstanding the uncertainties as to exact benefits of pure water in these respects we know that they are great and that there is no lack of evidence to show the imperative duty of every city to provide its inhabitants with a water supply of unquestioned purity.

Time was when a city might hesitate before launching upon the expenditure necessary to provide a water purification plant, lest its outlay should not prove to give the desired results, or in giving them be burdensome on account of needless expense that might perhaps have been avoided by a delay that would make available some improved and less costly method of treatment. Fortunately, there is no longer reason for hesitation on this account. Of course, it is to be expected that many improvements, b[illegible] as to efficiency and lowering of cost, that hav[illegible]en developed by the combined brilliant work [illegible]n-gineers, chemists and bacteriologists wit[illegible]e past few years, will continue for years to [illegible]e; but so will they in all other lines of engi[illegible]g and of industry. The improvements of t[illegible]e ture, there is reason to believe, will larg[illegible]e of such a character that they can read[illegible]y adapted to the best methods now in vogue.

The advances in water purification are re[illegible]ably well illustrated by recent events pert[illegible]g to the water supply of New York City. [illegible] many years ago it was generally believed [illegible] the Croton supply was of such high char[illegible]r that little more could be asked for it. As Am[illegible]-can ideas of what constitutes a pure w[illegible]r supply were raised to a higher plane, and [illegible]s the population increased in the Croton drai[illegible]e area, apprehensions arose lest the City of [illegible] York was not supplying its inhabitants with [illegible]s good water as they had a right to demand. [illegible] it was thought that by the sanitary policing of the drainage area and by buying up the most menacing of the property contiguous to the streams and lakes and entirely removing these sources of pollution, the water could be rendered safe for many years to come. It would be interesting to know how many millions of dollars have been expended for this purpose, but unfortunately New York, in common with most other American cities, has no system of accounts or records that makes such useful information as this would be readily available to its citizens. In fact, we may go further and say that in the case of New York it is very doubtful whether this information could be obtained with exactness, if at all, short of putting expert accountants on to dusty and inaccessible books. Whatever the cost, and however justifiable the results, the fact remains that the condemnation of land and the policing of stream and reservoir shores in the Croton drainage area has not sufficed to keep the water safe. This opinion is held by the Commissioner of Health, by the many engineers who have reported for city departments and for civic associations during the past half-dozen years, and must be shared by any competent person who gives careful attention to the typhoid case and death statistics of New York City. Moreover, and in addition to all the more decidedly health reasons for improving the character of the Croton water supply, there are those esthetic reasons pertaining to the color, odor and clarity of the water, which are being given increasing significance in these later days. The time has passed when a city, great or small, is justified in supplying its citizens with a water that is in any way repugnant to sight, taste or smell, even though it be free from the infection of specific disease.

But the statements made in the last paragraph, regarding advances in water purification as illustrated by New York City, are in some respects less notable than those evidenced by the plans for purifying the Croton supply which have just been submitted by eminent engineers to the Board of Estimate and Apportionment. These plans contemplate a rate of filtration and a lowness of cost that are indeed surprising and that give promise of an even greater hastening than has yet been seen of the day when every American city drawing water from surface sources will insist on its purification. We need not repeat here the details of the plans nor of the careful and interesting experiments which warrant the assumption of such a high filtration rate and so low a cost. It is sufficient to point out, first, that the long period of sedimentation in large storage reservoirs already and for many years enjoyed by New York City, and also the general freedom of the Croton water from marked turbidity and any high degree of pollution, are favorable to a higher rate of filtration than has heretofore been considered feasible for the ordinary type of slow-sand filters. Second, that ample provision for emergency use of further sedimentation, supplemented as the need arises by coagulation, is also favorable to a high filtration rate. And, third, that the small area of filter beds to be cleaned, and the small area necessarily out of service while the cleaning operation is in

progress, combined with proposed new or comparatively new methods of cleaning and with the preliminary treatment given the water, explain why a low operating cost may be expected.

One other remarkably significant thing connected with the New York water purification experiments demands notice. That is, the high cost and the uncertainty of continuous successful operation of the plant installed at private expense to test the availability of electrically-produced ozone as a means of bacterial improvement of the water supply. The cost per 1,000,000 gals., and that, as we understand it, for the production of the ozone alone, without allowing for the expense of necessary preliminary filtration or for capital charges, is the enormous figure of $20 per 1,000,000 gals. And even then, instead of producing the sterile water claimed by the ardent though unreasonable advocates of ozonization, the bacterial reduction was only from 100 per c.c. to 7. Now, of course, 7 bacteria per c.c. are nothing to give one much anxiety, and there need not, under ordinary conditions, be any particular worry over 100. But nevertheless, in view of all that has been claimed for ozonization, the figures given in this New York report are very discouraging to the process. Not only that, but, as a further discouragement, they are in a general way exactly in line with experience elsewhere. Over and over again one sees it stated by disinterested engineers, in connection with the few ozone plants that have been tried, either experimentally or as adjuncts to municipal works, that their cost renders them quite impracticable and that there is no hope for their general use until such time as very material cheapening in the production of ozone has been effected.

It may be that more complete details regarding these New York tests will show that the ozone treatment at the Jerome Park Reservoir was in some way at a disadvantage and that the conclusions to be drawn from these tests are not of general application. It is to be hoped, but we have no reason to believe, that such is the case. Not every one understands that, as thus far developed, the ozone process is not practicable except for a water that is either remarkably free from suspended matter at the outset, or else has been made so by filtration. In nearly all the ozone plants that have come to our attention filtration is employed. In such cases, the high cost of the ozone treatment, in itself generally prohibitive, is added to the cost of filtration. The filtration, of course, may be rapid, oftentimes, and therefore relatively cheap, but we believe that the instances are rare when, even with a reduction in the cost of the ozone treatment, it would not be cheaper, if not safer, to adopt more thorough filtration and let the ozone treatment await further development before attempting to use it.

Coming back, in conclusion, to the question of an improved water supply for New York City, we feel like offering our hearty congratulations to the citizens of the American metropolis, and to all the engineers and others who have contributed toward making feasible at an early date a thoroughly safe water supply for the city. The plans for the new Catskill supply, as our readers know, also provide for a purification plant. But that supply will not be available for many years to come. If the Board of Estimate and Apportionment promptly grants the request of Commissioner O'Brien for the necessary funds, 400,000,000 gals. of water per day, free from any suspicion of infection, free from odor, color and taste, and in every way acceptable, will be available only some two years hence. Notwithstanding the present financial stringency, this request for an appropriation certainly deserves favorable action. Had a similar request been granted a year earlier, a pure water supply would have been that much nearer, but the experimental work and the further studies of costs and of methods partly make up for the delay. With the endorsement of so many eminent engineers and sanitarians as this general plan for filtering the Croton supply has now received, there seems to be no occasion for further question or postponement.

LETTERS TO THE EDITOR.

Sunfish, Typhoid Fever and Malaria.

Sir: In your issue of Nov. 7 you publish a clipping from the Kansas City Star which states in substance that certain ponds and streams in this vicinity had, under my direction, been stocked with sunfish for the purpose of destroying the typhoid fever bacilli in the water. While all informed persons would of course recognize such a story as a newspaper hoax, yet the wide publicity given it leads me to give the following explanation of its origin:

The State Fish Commissioner, at the request of the representative of the State Board of Health in charge of mosquito investigation in this State, sent a number of sunfish to this city to stock some of the ponds in this vicinity. They were consigned to the Bureau of Health, which assisted in their distribution. The fertile imagination of some reporter led to the publication of the report that they were to be used in the prevention of typhoid. The story has grown with each recopying. As it is possible that some persons (including the gentleman from Boston) may have taken it seriously I hope you will give this the same publicity as the article referred to and that other engineering, sanitary and medical journals may copy.

Very truly yours,

J. F. Edwards,

Pittsburg, Pa., Nov. 9, 1907. Supt., Bureau of Health.

Patents on the Use of Clay and Alum for Waterproofing Concrete.

Sir: Being in receipt of numerous communications from individuals and corporations relative to my invention relating to waterproof Portland cement mortar and concrete and processes of producing the same, described in your issue of Sept. 26, I desire through your columns to publicly record the fact that I have not in any way dedicated to the public the rights to manufacture and use such cement mortar and concrete and the processes of producing the same, but that I have explicitly reserved to my own use all rights to the same and have protected such rights by application for Letters Patent in the United States Patent Office.

A general notice is hereby given that any unlicensed use of this cement mortar and concrete or the processes of making same waterproof is a direct infringement of my rights and as such will be prosecuted to the full extent of the law.

Yours very truly,

Richard H. Gaines.

Chemist, Board of Water Supply, Engineering Bureau, Laboratory, 147 Varick St., New York City.

[Mr. Gaines has stated that these steps toward protecting his process for rendering concrete impervious were also advised to prevent other individuals from obtaining patents on this and similar methods and from then interfering with the free use of the process in the work of the city of New York.—Ed.]

Disintegration of Concrete Structures in Sea-Water Between High and Low Tides.

Sir: In connection with the question of the disintegration of concrete along tide waters, referred to in your issue of Oct. 31, 1907, it is interesting to note a report of Consul-General R. P. Skinner of Marseilles. This report appears in "Monthly Consular and Trade Reports" for October, 1907, and describes Lime-"Beton," a cheap and enduring material for construction work used largely in France. The first paragraph of Mr. Skinner's report is as follows:

> Lime beton has been in longer and more general use than cement concretes. It was a first-class material when made with ordinary quicklime, and since hydraulic lime has been used it is better. It is a cheaper composition than cement beton or concrete, easier to work, and if the initial load be not too great it is, for nearly every purpose, just as good. A good lime beton can be obtained by mixing mortar and stones, gravel, or cinders; mortar and good sized stones making the best composition. Probably one-half of the houses in Marseilles have been built of this material, and thousands of the older buildings, many hundreds years old, are held together by ordinary lime. Walls built of quicklime beton must be laid up slowly, but with hydraulic-lime beton they can be erected as fast as masons can work. The solidity of lime beton construction is shown by the sea walls and docks in Marseilles, where masonry of this kind may be seen both above and below sea water, the most difficult test to which building material can be subjected.

While only the last sentence of this paragraph seems to have any bearing on the question in debate, it is, nevertheless, instructive to note that lime concrete seems to have some advantages over cement concrete. Although Mr. Skinner does not say anything very definite relative to the actual condition of the lime "beton" in the sea walls and docks at Marseilles, the inference is that it is very satisfactory.

Yours very truly,

Wemlinger Steel Piling Co.,

J. R. Wemlinger, President.

11 Broadway, N. Y., Nov. 13, 1907.

Use of Lime Mortar in Place of Cement.

Sir: Mr. Shaw wants practical experience as to how lime and Portland cement act together. The following facts may be of interest:

Twenty years ago I was acting as Superintendent of Works at the reconstruction of one of the large public works in Montreal, at which building the first Canadian Portland cement was used. The mortar there used was made in the following manner: 3 parts of sand to 1 part of cement was made into mortar; then 1 bbl. of Montreal lime shell to 3 bbls. of the same kind of sand; then equal parts of cement mortar and lime mortar were mixed together and properly tempered. This combination of mortar was used both for the rubble foundations and the brick superstructure, and stands to this day, getting sounder as it ages. One month after building this mortar a stone mason was sent to cut out about a superficial foot to find out how it was acting. The mason had no difficulty in cutting the brick, but the beds of mortar remained, and were found to have the usual hardness and setting powers that ordinary cement mortar had. However, Mr. Shaw has the above specification and can refute or corroborate this letter. This mixture will run about 8 bbls. of shell lime to the ton, so that with the costs named by Mr. Shaw ($8 per bbl. for cement and $3.50 per ton for lime), the saving in building this work may be determined. There is no occasion to use any facing or brick facing, as it is a matter of cost.

Very truly yours,

O. Fraser.

Port Colborne, Ont., Oct. 28, 1907.

Sir: Referring to inquiry in Engineering News of Oct. 24 by Mr. Shaw, of Zacatecas, Mex., for information as to use of lime mortar in place of cement:

Two or three years ago Engineering News (Feb. 9, 1905.—Ed.) contained an item telling of the expedient adopted in a similar case by an engineer who erected a dam in Egypt. He mixed finely ground clay and hydrated lime in equal quantities and thus made a puzzolan cement that set well under water. Tests made showed it to possess great strength.

He was not the first by any means to do this. Many centuries ago masons mixed common dust with lime mortar to give it hydraulic properties. The Romans mixed lime with ashes from the volcano near Puzzuola and cement made in a similar manner is called puzzolan. In several very old English books I have read that masons should mix fine dust with their lime before making mortar to use in the interior of heavy masonry walls. Inspectors, however, were apt to stop such a practice, considering the dust an adulteration, whereas it really made a cement that would set rapidly. If some such expedient were not adopted there was danger of the lime mortar not hardening for years.

About six years ago the writer mixed fine brick dust and hydrated lime together and made a fairly satisfactory cement for a small concrete job in the mountains in the west where Portland cement could not be obtained. By the time it had been brought in the cost might have been ten or fifteen dollars per barrel. It was a limestone section and the miner had made some good lime and from a shale bank near by obtained material for some fine brick.

Many writers have described the condition of the interior of old masonry taken down after years of use and it is known that lime mortar has been found soft after having been in place for fifty years or more. It is not likely that the ventilation pipes suggested by Mr. Shaw would help harden the mortar for more than a few inches from their ends. Two expedients therefore suggest themselves to the writer. The one is to experiment with the manufacture of a puzzolan cement if suitable clay can be had near by. As it will be affected by the atmosphere and is all right when constantly moist, he should face all that part of the dam not covered with water, with a Portland cement concrete or with stone or brick laid up in Portland cement mortar. The second expedient would be to manufacture sand lime brick and construct his dam of that material.

Yours truly,

Ernest McCullough.

Chicago, Ill., Oct 26, 1907.

An Insect-Proof Tent.

Sir: The article by Mr. Liebel in your issue of Oct. 24, 1907, in regard to the Madeira & Mamore R. R. in Brazil, prompts me to suggest to brother engineers the use of an insect-proof tent in the tropics.

I found in use in Alaska, where mosquitos and gnats abound in summer, a tent that filled a long-felt want. It has the form of the ordinary wall tent, but has a floor of canvas sewed to the walls. Instead of the open "flap" for ingress and egress, there is a circular hole with a running cord, working like that in the old-fashioned reticule. Ventilation is effected by means of "windows" of mosquito netting. In tropical countries I have used with great satisfaction such a tent with windows in both sides and in the rear and the front. The netting should be of the best quality, and doubled.

I would suggest windows 16 x 10 ins., provided with curtains, one on the inside and one on the outside. The curtains are sewed to the top of the window and are fastened up by means of a spring button, such as used on some storm coats. The object of the double curtains is to afford ample protection against rain accompanied by wind, and to allow the occupant to close the window at night on the inside of the tent in case of a sudden rainstorm. No ridge pole is used. The tent is sustained by a rope passing through galvanized iron rings attached to the ridge. The poles are placed on the outside of the tent. Where there is a scarcity of trees and the camp outfit has to be transported by mule or porters, it is very convenient to have the poles made to telescope or with hinge and clamp in the middle. In the tropics it is economical to use some material that will not "mildew" or rot quickly. Where the tent is used for office or drafting room ventilating windows in the roof are advisable. A good fly is indispensable.

Add to your camp outfit this tent and a rubber mattress and you will greatly diminish the hardships of the railroad engineer in the tropics.

You may imagine the comfort of the above-described tent where the mosquito, gnat, gegén and many other marauding insects make sleep impossible in the open or in an ordinary tent. When one is securely enclosed in this well ventilated "bag" the mosquito ceases to be a burden, and all fear of attack of venomous insects or reptiles is at an end. J. L. P.

Los Angeles, Cal., Oct. 30, 1907.

The Measurement of Water on Irrigation Projects.

Sir: The subject of measurement of water on irrigation projects is of particular interest at this time to engineers of the Reclamation Service who are putting in operation large irrigation systems. I have been much interested in Mr. Fortier's article and your editorial in your issue of Sept. 19, and have noted with interest a letter by Mr. Clemens Herschel in your issue of Sept. 26.

I am much interested in the views of so eminent an authority as Mr. Herschel. In theory I believe his scheme for giving the settler direct interest in the economy of water by charging him in proportion to the amount he uses is excellent. There is apparently nothing to prevent the carrying out of a plan of this sort, and on the Truckee-Carson project, at least, it is the intention to charge water users in proportion to the amount of water taken, setting a maximum amount beyond which the settler cannot go and setting a minimum amount for which charge will be made, so that it will not be possible for a land owner to hold land for speculation without placing it in cultivation.

In initiating any such scheme there is generally much complaint on the part of farmers, usually on account of the system being new to them, but as they become used to its administration it is so evidently to their advantage to practice economy that all opposition soon subsides.

The idea which seems to dominate the average farmer of the West, an idea ground into him by many years of bitter experience, is that he must get and make use of every drop of water which is passing at the moment. He has no knowledge of or interest in the water stored in the mountains which will be coming down stream all summer. He has seen so many summers pass and the rivers go dry before his second crop has been cut that he believes only such a system as he has always known can succeed. With the Government building storage reservoirs, canals and ditches for the distribution of this storage water to the land, all this should change. Every farmer should know that a certain number of acre-feet are being stored and held for his use, to be delivered on his order, and that no overdraft beyond that which he is credited with will be allowed. If it becomes perfectly evident to him that every acre-foot of water which flows on the hillsides has an owner among his neighbors he will more speedily become reconciled to his own allotment and will make it suffice.

I remember visiting the valley of a stream in Colorado a few years ago before the storage reservoirs now supplying the valley had been built. Then the streams ran low in summer and during the spring when water was plentiful everyone "hogged" all he could get and fairly swamped the country for a few weeks. No one knew how long the supply would last and each man tried to outstrip his neighbor in securing water. Now all this is changed. Most of the farmers own stock in a reservoir, know how much water there is left of their supply and there is no haste about using the amount deposited to the credit of each man, for that amount is just as definite and just as sure as is his deposit in bank.

Farmers are gradually learning how to measure water and as their knowledge of water measuring increases their objections to any system of measured quantities gradually is overcome. On the Truckee-Carson project all water is measured over weirs, the ditch-riders making readings once or twice a day and being frequently checked in their measurements by the farmers themselves. There is apparently no difficulty in this method and there have been no disputes of any note regarding the amount of water delivered. Each ditch-rider reports daily the amount of water he has delivered, and ledger accounts are kept in the central office with each farm. No restriction is made upon the amount new land is allowed, provided there is no waste, but with a farm once subdued the farmer will be strictly held down to the maximum amount allowed in our contracts, provided this amount can be put to beneficial use.

We are in sad need at this time of some cheap method of measuring water; that is to say, some cheap instrument which will record the flow throughout the day. One objection to the Venturi meter is its cost. The cost of our irrigation works on this project will be less than $30 an acre and it is manifestly bad business to ask the owner of a forty-acre tract to pay $350 for a machine to measure the water to him. This would mean an additional cost of nearly $9 per acre, or practically one-third the original cost of his water-right. If some ingenious engineer can invent a water meter which can be used on irrigation ditches where sun, wind, rain, sand, animals, floating weeds and every other conceivable obstacle is present to interfere with machinery, he will be able to sell many of these machines to irrigation projects.

There is no question regarding the necessity of measuring water—we now need the means of measuring it accurately and cheaply.

Very respectfully,

Thos. H. Means,
Engineer in Charge of Operation.

Fallon, Nev., Oct. 19, 1907.

Engineering and the Commercial View.

Sir: In your editorial of Oct. 24 on "Engineering and the Commercial View" you refer to the advertising expert as "the remote successor of the county fair barker and the patent medicine charlatan." Now as the barker may conceivably be of some service to all, I have no quarrel with that part of your definition; but I do believe the imputation contained in the phrase "patent medicine charlatan" to be unjust.

The carrying on of a successful engineering manufacturing enterprise consists of three fairly distinct steps, viz.: First, the invention and design of apparatus; second, its production; and third, the developing of a market and the consummation of sales. To carry out the first process and provide equipment for the second usually requires the investment of an immense amount of capital before the third process, from which all returns and profits are derived, can even begin. The manufacturer may have engaged the most able engineers to carry on researches on which to base designs, he may have invested hundreds of thousands of dollars in modern plant and special tools in order to manufacture well and cheaply, but until purchasers appear, the whole investment is a potential loss.

Engineers who get up improved machines, methods or products, see the need for them; but then, such men are specialists in their own particular lines. Other people may not perceive why the new method or apparatus is any better than the old and familiar way which it seeks to displace, and they may not even take the trouble to investigate; they are probably preoccupied in the making of something else. The originator of the improved apparatus must take the initiative in informing these people about his wares and in educating them as to applications and advantages. Only in this way can he reduce the time and waste that always intervene between the perfection of a device or process and its general use.

It is at this point, I would submit, that the services of the "advertising expert" become valuable. His specialty is the efficient and economical dissemination of ideas. The purchaser must be informed about the article, its uses and merits, before he will buy. It is expensive to show it to him or to explain or demonstrate it personally, especially if he (collectively speaking) is scattered in different parts of the country. To a large extent the printing press will do the work as well, and, if intelligently handled, is much cheaper.

Now, then, just as some persons acquire proficiency in the imparting of information to the young and become teachers, while others show ability in analyzing and presenting matters in equity and law and become lawyers, and still others are proficient in relating and discussing current events and become editors and writers, so some men take it upon themselves to specialize, collate experience, analyze results, classify facts, and become adept in everything that pertains to the presentation of manufactured products to possible buyers by means of printed words and pictures and with the view to making the greatest number of profitable sales. In so far as it economizes time, labor and expense, this is a useful and, under modern conditions, a necessary work, deserving of a place in the social economy.

Advertising tends to reduce rather than increase the percentage expense of selling. It reduces the risks of capital and the loss from idle capital. It tends to establish high standards of business morality, since misrepresentations go on record, and can afterwards be used to the offender's disadvantage. It tends to expedite and simplify the work of both buyer and seller. It leads to the education of the buyer as to the latest and most improved processes and methods. It removes large... the personal factor and encourages intelligent and dis...minating buying; bulldozing, wheedling and jollying impossible in an advertisement; it is effective in pro...portion to its content of fact and argument. It leads to per...fection of the product in order that the latter may have the strongest claims to the buyer's consideration. It stimulates all producers to a high level of attainment. And, finally, it accelerates engineering progress and makes engineering more profitable, thereby multiplying and popularizing the benefits of science.

Respectfully yours,

Geo. H. Gib...
The Geo. H. Gibson Co., Advertising Engi...
Tribune Bldg., New York City, Oct. 26, 1907.

[Of course this spirited defence of the advertising expert does not at all attack the statement referred to of our editorial. We spoke of *engineers* and engineering firms resorting to the employment of publicity men for drawing trade, and suggested the impropriety of this procedure. To question the correctness of utilizing the services of advertising specialists in selling machinery or supplies was far from our mind; and on re-reading the passage in question we do not find that it carries such an implication.

The incidental charge that something objectionable is conveyed by the phrase "patent medicine charlatan" might almost lead one to believe that our correspondent has been stirred up by the fight on proprietary remedies which several "home"-magazines have been waging. The charlatan (= One who pretends to knowledge, skill, etc., which he does not possess; a quack, . . .) who sold wonderful cure-alls to honest country-people by the mere force of persuasive laudation, and the barker who drew the last pieces of silver out of the pockets of the crowd by arousing its curiosity through his striking harangue—were they not publicity men more than anything else? Did they not make a specialty of the dissemination of ideas (efficient and economical from their employers' viewpoint)? Surely it is no disparagement to present-day merits if we trace back the ancestry of the advertising expert to humble beginnings! For that matter, the bill-poster might have been included in our statement, without great error, and also the herald, whose trumpet graces our correspondent's letter-head.—Ed.]

THE IRRIGATION AND DRAINAGE INVESTIGATIONS carried on by the Office of Experiment Stations, U. S. Department of Agriculture, under the direction of Mr. Elwood Mead, M. Am. Soc. C. E., since 1898, will hereafter be conducted in two divisions. This change follows the resignation of Mr. Mead to take charge of Government irrigation work in Australia. Under the new arrangement, Prof. Samuel Fortier is Chief of Irrigation Investigations, and Mr. C. G. Elliott, M. Am. Soc. C. E., is Chief of Drainage Investigations. Professor Fortier has been in charge of the Pacific District of the Irrigation and Drainage Investigations, with headquarters at the University of California, Berkeley, Cal. Mr. Elliott has for a number of years past had direct charge of drainage investigations. Both Professor Fortier and Mr. Elliott will report directly to Dr. A. C. True, Director of the Office of Experiment Stations. The irrigation work will continue to be concerned, as heretofore, with (to quote from a circular issued by the U. S. Department of Agriculture) "(1) dissemination of practical information, (2) scientific and technical investigations, and (3) reporting on irrigation conditions in certain districts." These investigations will be particularly important from now on, in view of the fact that it is expected that by the close of 1908 "5,000,000 acres of land provided with water for irrigation will be available for settlement." Technical investigations will cover such subjects as evaporation, seepage and distribution losses of the applied water, the relation of irrigation water to the quantity and quality of crops and to different soils, and to "the measurement, conveyance, storage and distribution of water on farms, and the various devices used for pumping." The drainage work will include a study of past and present drainage practice, and will also be designed to assist "farmers, communities and States in the initiation and direction of drainage improvements." Plans for draining some 2,000,000 acres, principally east of the Mississippi River, have been made in the Office of Experiment Stations during the past year. A stimulus to demands for drainage investigations will doubtless be caused by the drainage convention at Washington next week.

DESIGN FOR THE HENRY HUDSON MEMORIAL BRIDGE: A CONCRETE RIB ARCH OF 703 FT. SPAN.

Plans have been prepared by the Department of Bridges of New York City for a concrete arch bridge of remarkable size. This is the bridge proposed to be a tercentenary memorial of Henry Hudson's voyage up the river that now bears his name. It is to cross the western end of Spuyten Duyvil Creek (which separates Manhattan Island from the mainland to the north) and will form a part of New York City's elaborate driveway and park system on the bank of the Hudson, the Riverside Drive. The object of the bridge, to serve as a monument of an important historical event, calls for a monumental structure, of course, and every endeavor was made in the design to fulfil this need. However, the surprisingly bold character of the design, that is, the utterly unprecedented span of the main arch, is not a direct result of this attempt, but came about in a manner which will appear directly.

The movement for a Hudson celebration and a permanent memorial was originally stimulated by a private association of citizens, who early settled upon a high-level bridge over Spuyten Duyvil Creek as the most appropriate memorial. Their agitation finally resulted in the city's accepting the proposal, and committing itself to the bridge project.

Meanwhile a suggestion for a steel arch bridge of 400-ft. span had been sketched by Mr. A. P. Boller, of the engineering firm of Boller & Hodge, for the Hudson Memorial Association. Later, a preliminary study of the subsoil conditions showed that such a span could not be built, as suitable foundation strata were far too deep below water-level at the assigned pier locations. Mr. Boller being commissioned by the city authorities to work out a further design for the bridge, he drew plans for a two-hinged steel arch, footing on the extreme rock outcrop on either bank. The span center to center of hinge-pins was 825 ft., and the rise about 150 ft. The arch had parallel chords and a simple web system.

The creek channel at the proposed crossing is some 550 to 600 ft. broad. It constitutes a deep gorge between the hills to the south and north, the greatest depth to rock being about 180 ft. below mean high water. Permanent foundations in the water were not thought feasible, under the circumstances. Along the northerly bank extends the four-track main line of the New York Central & Hudson River R. R. As is shown by a profile of the soil strata (Fig. 4, sketched from diamond-drill borings made in 1907*) the foundation conditions riverward of the railway roadbed are difficult, and it was necessary to place the abutments on the land side. The steep slope of the surface of bed-rock made it seem advisable to save excavation by increasing the span sufficiently to place the abutments on outcropping rock. Thus the span of the original design was determined as 825 ft. This span, while large, is conservative for a steel structure, being within the limits of what has already been achieved. The plan was submitted to the Art Commission of the City of New York, whose approval of the esthetic side of plans for public works is required before such plans can be carried out. The Commission rejected the design, mainly on the ground that a permanent monument, such as this bridge is to represent, demands a more permanent material than steel. The city's Department of Bridges thereupon proceeded with the formulation of new designs. The present design is the result. It has just been submitted to the Art Commission for approval. Fig. 1, herewith, is from a reduced photograph of the sketch submitted to the Commission for this purpose. It represents the structure as seen from the northeast, looking out over the Hudson River and to the Palisades on the New Jersey shore beyond.

This design employs concrete in place of steel for the principal elements of the structure; notwithstanding this change of material, the great arch over the creek is retained, though by means of 20-ft. excavation for the abutment foundations the span-length is pared down to a width (in the clear) of 703 ft. In steel, a span of this magnitude, or even of 825 ft., is substantially within the limits of approved construction (the upper Niagara arch, 840 ft. c. to c. of hinges, is the largest existing steel arch; the design for the Hell Gate bridge contemplates a 1,000-ft. arch). But in concrete there is nothing even remotely approaching in magnitude the proposed span. The Grünwald bridge over the Isar at Munich, Germany, 230 ft. in span, is the largest completed concrete arch. The Walnut Lane concrete arch bridge, now being built, has a slightly longer span, 233 ft. between faces of abutments. These spans become insignificant, even trivial, when compared with that now proposed for the Hudson Memorial Bridge.

A better idea of the boldness of the proposal is had from a comparison with the general field of masonry arch construction, since the problems of design and erection for arches of stone and concrete are in a measure the same. The Cabin John arch of the Washington aqueduct, 220 ft. in span, built about half a century ago, was for a long time looked upon as an exceptional achievement, being the largest stone arch in the world. Only in the last eight years has it been exceeded, and there are now three larger spans in stone, besides the 230-ft. concrete arch at Grünwald: Adda, 230 ft.; Luxemburg, 278 ft.; and Plauen, 295 ft. In fifty years, designers have ventured only one-third beyond the limits set by the Cabin John arch, and only in three cases have they found it necessary. Now, in one leap, the present limit is to be multiplied by two and one-half.

The design for this remarkable structure can be summarized very simply: The arch has open spandrels, except near the crown. The concrete ring is 725 ft. in span between centers of skewbacks or 703 ft. in the clear, with a center-to-center rise of 177 ft. It is a massive concrete rib 70 ft. wide, with a crown thickness of 15 ft. and a thickness at skewbacks of 28 ft. The rib is shaped to fit the possible pressure lines so closely that tension can never occur in any part of the ring. The immense dead weight makes the influence of live-load almost negligible, and the possible effects of temperature variation, etc., are relatively small. Steel reinforcing ribs are built in, however, primarily to reduce the compressive stress on the concrete or (in another aspect) to reduce the dead weight of the structure. The steel is uniformly distributed over the cross-section of the arch. It is arranged as sketched in Fig. 5.

FIG. 1. 703-FT. CONCRETE ARCH DESIGN FOR THE HUDSON MEMORIAL BRIDGE OVER SPUYTEN DUYVIL CREEK, NEW YORK CITY.

The arch carries a double deck. The upper or main deck is a highway floor, 80 ft. wide between railings; it has a 50-ft. roadway and two 15-ft. sidewalks. The lower deck is to carry four tracks of a rapid-transit railway, but as no such line is yet in prospect the lower floor system is not to be put in place at first, but only the necessary connections provided for it. Both decks have steel framing, comprising plate-girder stringers framing into floorbeams. The floorbeams are supported in part by steel columns which foot on the steel reinforcing ribs of the arch and in part by concrete curtain walls carried up to close off the spandrel-spaces of the relieving arches (secondary arches) and the space above the main arch-ring in the crown region where the system of relieving arches is interrupted.

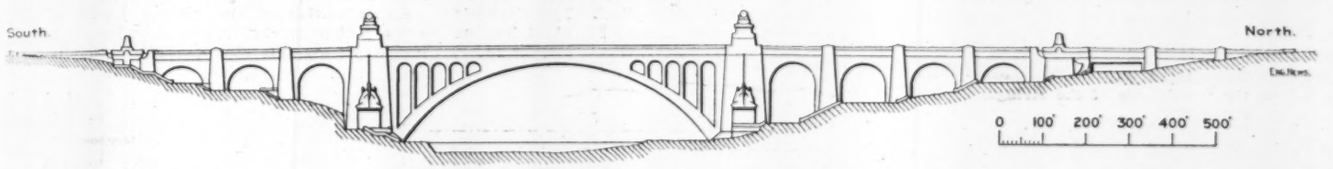


FIG. 2. GENERAL ELEVATION OF HUDSON MEMORIAL BRIDGE.

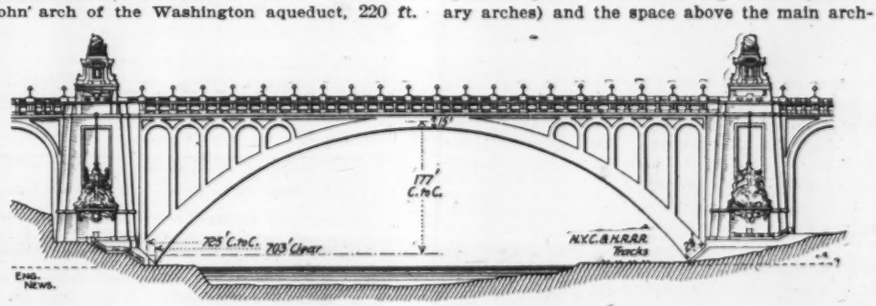


FIG. 3. ELEVATION OF THE 703-FT. ARCH.

The posts or shafts over the main arch ring, between which the relieving arches are sprung, are each composed of a pair of concrete piers, 8 ft. thick in the direction of the length of the bridge and 22 ft. wide transversely, the two being set flush with the respective sides of the arch ring, so that a space of 26 ft. is left in the center between them. Each of these piers is hollow, however, and is a concrete pier only in appearance. It contains six steel columns (four angles

*A partial profile about 200 ft. west of the site, at the draw-bridge of the New York Central & Hudson River R. R., Spuyten Duyvil division, is given in Engineering News of June 14, 1900, p. 398.

latticed in square arrangement) which are each filled with concrete and then connected by a 12-in. concrete enclosing wall which forms the exterior surface of the pier. The concrete filling of each column is figured to carry its share of the load. The twelve steel columns of each pair of piers are connected at the foot by four transverse plate-girders, which in turn rest upon the reinforcing ribs of the main arch, and distribute

tion of ring thickness, and the proportioning of the curve of rib, were the result of successive approximations. The influence of the live-loads in shifting the pressure line is so small that the live-load moments had very little bearing upon the ring thickness. The limiting compressive unit-stress in the concrete was the most weighty factor; the two objective points of safe maximum stresses and least combined cost of

The stresses due to temperature changes were also fully calculated for each section. A variation of 20° F. above or below mean temperature was assumed, but the calculations were also carried out for a variation of ± 30° F. The influence of the shrinkage of the concrete in setting was calculated in exactly the same way as for temperature change. On the basis of French experiments, the maximum shrinkage to be

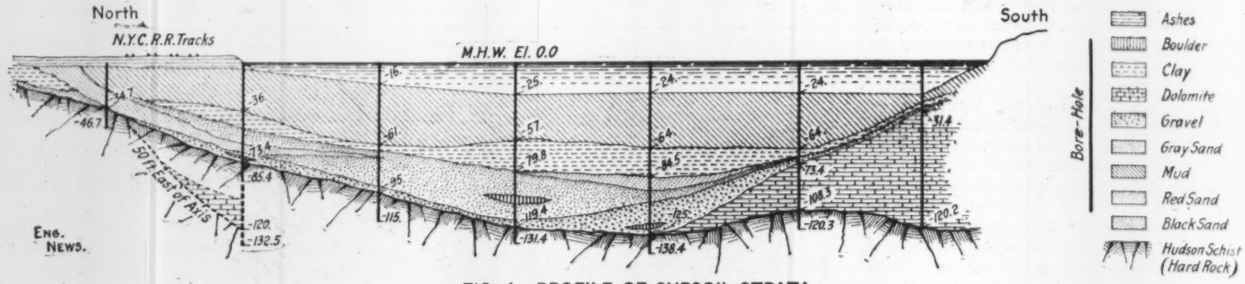


FIG. 4. PROFILE OF SUBSOIL STRATA.

(Strata given from Diamond Drill Borings on Line 50 ft. West of Axis of Bridge.)

through the arch ring the load of the superstructure.

Thus, so far as concerns the portion above the main arch ring, the bridge is in effect a steel structure, partly protected by concrete and surfaced with a concrete floor. The concrete-filled posts and the relieving arches are the only exception to pure steel construction in this part of the bridge. The relieving arches, though they serve to carry that part of the floor load which comes down through the spandrel walls, are mainly mere bracing members. The bridge is a steel viaduct carried on an immense arch ring.

The only further details requiring mention here are the following: The relieving arches, spanning about 30 to 35 ft. in the clear, have reinforced concrete rings. The deck of the roadway consists of plain concrete arches sprung between the stringers. The sidewalk floor is made of reinforced-concrete slabs separately molded, and bolted on the top flanges of the stringers. The roadway is paved.

The approaches to the great arch are formed of a succession of 100-ft. circular arches, and involve no features calling for special remark. The roadway on the approaches has a grade of 1½% from either side up toward the center; over the main span a vertical curve unites the slopes. By adopting this gradient, a notable gain in center height of arch was secured, as compared with the first design, and the arch stresses correspondingly reduced. The 100-ft. arches are of concrete, probably unreinforced. The piers between them, detailed to harmonize with the treatment of the two main piers, are faced with stone in rusticated coursing. All other surfaces of the structure are concrete. This is expected to give a marked relief between the pier faces and the arch and spandrel faces.

In fact, the architectural side of the design was worked out with very great care, as befitted a monumental structure. Mr. Whitney Warren was retained by the Department of Bridges as Architect for this purpose. The result is fairly well represented in the view Fig. 1, and further description is unnecessary.

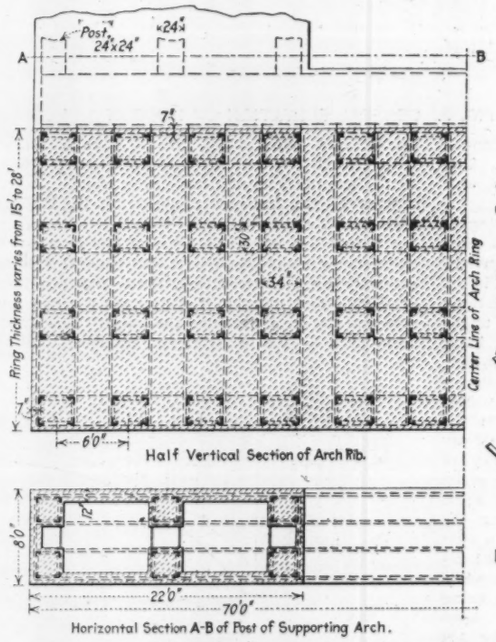
Returning now to the structural consideration of the great arch, we may describe the arch rib as being practically a circular segment in the profile of its center line. The center-line radius is 450.94, except for a short distance at the crown which has a slightly greater radius, 489 ft. The other principal dimensions have already been given, but together with the governing conditions as to load, etc., they are tabulated here:

Span, c. to c. skewbacks	725 ft.
Rise, c. to c.	177 ft.
Width of ring	70 ft.
Crown thickness	15 ft.
Skewback thickness	28 ft.
Reinforcement, mean	abt. 1¾%
Live-load	15,000 lbs. per lin. ft.
[Roadway and sidewalks, 75 lbs. per sq. ft. on 80-ft. width; four railway tracks, 2,250 lbs. per lin. ft. each.]	
Temperature variation	± 20° F.
Maximum shrinkage allowance	1/5000

The estimation of dead-load, the determination of ring thickness, and the proportioning of the curve of rib, were the result of successive approximations. The influence of the live-loads in shifting the pressure line is so small that the live-load moments had very little bearing upon the ring thickness. The limiting compressive unit-stress in the concrete was the most weighty factor; the two objective points of safe maximum stresses and least combined cost of steel and concrete were attained by adjustment of both the ring-thickness and the reinforcement percentage.

A concrete at least as rich as 1:2:4 was decided to be used, and for this the permissible compression, all sources of stress considered, was fixed at 750 lbs. per sq. in., the working stress allowed by the Bureau of Buildings of Manhattan Borough, New York City, for semi-looped reinforced-concrete work.

The computation of stresses was carried out on the basis of exact elastic analysis. Both a graphical and an algebraic calculation were made, being checked against each other both in the location of the several pressure lines and in the stresses. The graphical analysis followed the general course of Cain's method. The algebraic computation was used directly for obtaining the influence lines for horizontal thrust and for shear,



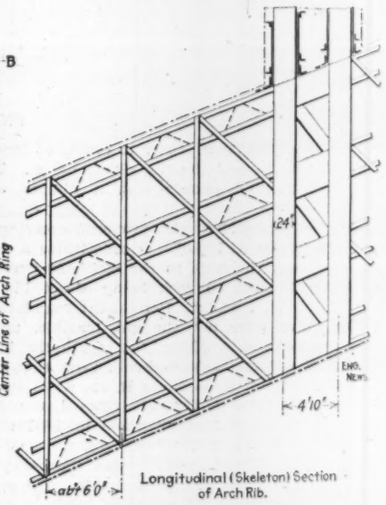


FIG. 5. SKETCH OF ARRANGEMENT OF REINFORCING STEEL IN MAIN ARCH, HUDSON MEMORIAL BRIDGE.

and from these were plotted the intersection curve and the envelope curves of the reactions.

The preliminary computations and designs were made with only two arrangements of live-load, namely, full and half span covered. For the final calculations, the actual positions of live-load for maximum moments at any given section were found [by drawing lines tangent to the envelope curves through the core-points of the section, in this case taken as the middle-third points, the limits of loading being given by the abscissas of the points where these lines cut the intersection curve].

pated was fixed at 1/5000, corresponding to a temperature change of about 30° F. The stresses due to the deflection of the arch were separately computed.

In all the calculations, the modulus of elasticity was taken to be 1/15 that of steel; calling 30,000,000 the modulus for steel, the concrete was credited with a modulus of 2,000,000 lbs. per sq. in. Then with 750 lbs. unit-compression in the concrete, the steel reinforcement is stressed to 11,250 lbs. per sq. in. as a maximum. This figure is subject to modification, however, to allow for the fact that the steel carries its own weight, and for the unequal distribution of the shrinkage of the concrete as the construction work progresses.

An indication of the general nature of the stress actions in the arch is given by the following list of extreme fiber stresses in the concrete at the crown section of the arch, taken from the preliminary calculations of the final design. In these figures, the effect of elastic shortening due to the stress is included in the load stress, but the bending stress from deflection is given separately:

Dead and live-load, maximum	600 lbs. per sq. in.
Temperature change, ± 20°	48 lbs. per sq. in.
Shrinkage, 1/5000	72 lbs. per sq. in.
Deflection	23 lbs. per sq. in.
Total	743 lbs. per sq. in.

Since the arch ring is never required to resist tension, the steel which is put into the ring is not

strictly reinforcement, in the sense of tensile reinforcement. No direct static conditions governed the proportioning of this steel work, therefore. The steel is employed primarily to ensure structural integrity or homogeneity of the entire arch ring, and being once provided it was applied to the purpose of reducing the compressive stress in the concrete. Since steel costs much more than concrete, a minimum amount of steel was desirable. The conflicting requirements were harmonized by successive approximations, which were begun with a crown thickness of 12 ft., and developed by repeated modification on the basis of the calculated extreme-fiber stresses and total costs. The final result is a steel percentage which will probably average about 1¾%. The distribution of the steel to suit the variations of total arch stress, however, will make the percentage at different sections vary from about 0.6% to about 2.9% at the crown.

The typical arrangement of the arch steel is shown somewhat diagrammatically by Fig. 5. There are twelve parallel rings, spaced 6 ft. apart transversely, each made up of four ribs braced together vertically by a triple-intersection web system. In general, the ribs are 34x30 ins., built of four 8 x 8-in. angles latticed inside with flat bars. The web members are 6 x 4-in. angles. There is an additional rib at each end in the middle line of each ring extending out from the skewbacks some 70 ft., to increase the amount of steel. At the crown the necessary increase of steel is provided by side-plates on the upper and lower ribs. The twelve rings are braced together transversely in groups of four by a triangular bracing system. The steelwork is designed so that it can be erected and swung before any concreting is done in the ring. Its weight will therefore not contribute to the stresses in the arch concrete. The steel ribs all have fully proportioned shoes at the skewbacks, which bear directly on the rock foundation and are anchored to it.

The steel columns concealed in the piers of the relieving arches are 24 x 24 ins. in section. Just above the arch ring each transverse row of columns is connected by transverse box-girders which transmit and distribute the load of the columns to the twelve reinforcing rings.

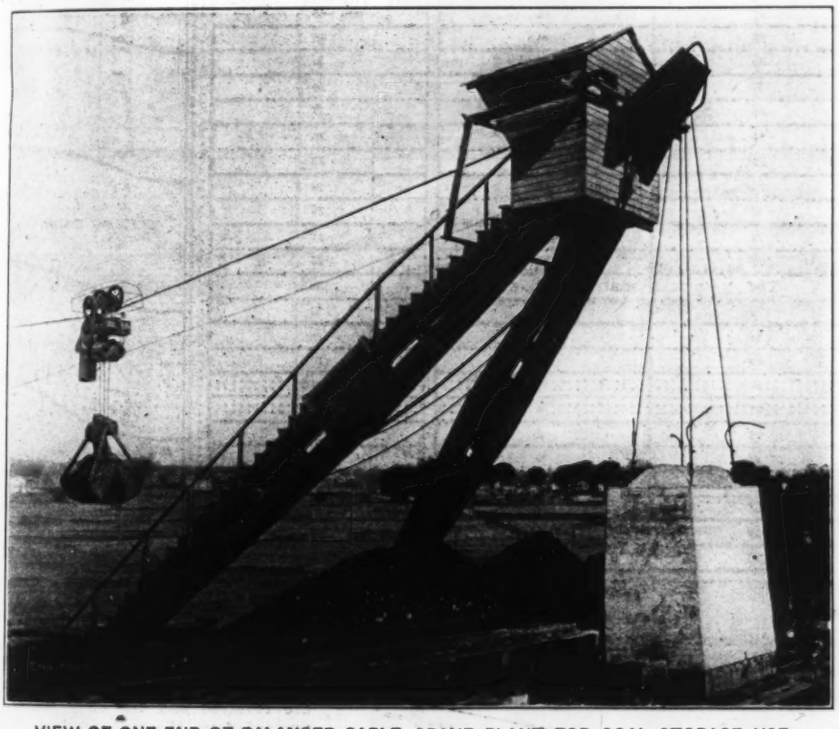
The weight of the steel in the arch, including columns and deck, counting a length of 750 ft., is about 12,000 tons; about 8,500 tons of this is in the arch ring. These figures are quite roughly approximate, of course. They are intended to include the weight of bracing and details, taken as 40% of the main sections. The corresponding volumes of concrete are 75,000 cu. yds. and 47,000 cu. yds., the former of which includes the foundations.

The total length of the bridge, including the approaches, is 2,840 ft. Its cost, excluding special ornamental features, is estimated at $3,800,000. About one-half of this is chargeable to the large arch and its superstructure.

The design of the bridge was carried out by the organization of the Department of Bridges of the City of New York, Mr. J. W. Stevenson, Commissioner of Bridges, Mr. C. M. Ingersoll, Chief Engineer, Prof. Wm. H. Burr, Consulting Engineer, Mr. Whitney Warren, Consulting Architect, and Mr. Leon S. Moisseiff, Engineer in Charge.

AN APPLICATION OF THE BALANCED CABLE CRANE TO A COAL STORAGE PLANT.

There have been described in Enginering News various applications of the balanced cable crane*, all of them, however, being concerned with such work as exacavation, construction, etc.



VIEW OF ONE END OF BALANCED CABLE CRANE PLANT FOR COAL STORAGE USE.

A recent application of the system, which is made by the Balanced Cable Crane Co., of New York City,† and is the invention of Mr. W. F. Brothers, President of the company, is to the handling and storage of coal at the yards of Marcy, Buck & Riley, at Watertown, N. Y. The yard is about 400 x 500 ft., and has a storage and reloading capacity of about 60,000 tons of soft coal or 100,000 tons of hard coal.

In principle, this equipment is the same as other balanced cable cranes which we have described. We show a view of one end of the cableway and the clam-shell bucket. The frame and counterweight at the other end of the cable are practically the same as in other installations, the counterweight being about 35 tons in this case.

The bucket may be lowered for filling directly into cars on the trestle; but usually the coal is dumped from hopper-bottom cars through the trestle, being carried by an inclined chute out towards the base of the main frame, and there being picked up by the bucket. In reloading, the bucket may be run directly over and discharged into the cars. The bucket has a capacity of 3 cu. yds., and when the photograph was taken contained 4,400 lbs. of coal. The carriage has a traveling speed of 1500 ft. per min., and a hoisting capacity of about 5 tons at 80 ft. per min.

Each pair of shear legs is driven by a 5 HP. motor and travels on a single rail. Each pair of shear legs travels independently of the other, and considerable diagonal latitude across the yard is possible. It will be noted that practically the entire yard area is available for storage.

*See our issues of Nov. 15, 1900, p. 328; May 12, 1904, p. 452; and Feb. 21, 1907, p. 205.

†135 William St.

REPORT ON THE FILTRATION OF THE CROTON WATER SUPPLY, NEW YORK CITY.

A slow sand filtration plant with a daily capacity of 400,000,000 gals., operating at a rate of 10,000,00 gals per acre per day, has been recommended for New York City in a report submitted to the Board of Estimate and Apportionment by Mr. John H. O'Brien, Commissioner of the Department of Water Supply, Gas and Electricity. This report, in turn, is based on one by Mr. I. M. de Varona, M. Am. Soc. C. E., Chief Engineer of the department named. Mr. de Varona's report is approved by Messrs. Rudolph Hering and George W. Fuller, M.'s Am. Soc. C. E., Consulting Engineers. Mr. William B. Fuller, M. Am. Soc. C. E., was engaged on the plans and estimates.

The various reports submitted were the result of a resolution adopted by the Board of Estimate and Apportionment on May 23, 1906, directing the Commissioner named to select a site for the filter plant and prepare plans and specifications therefor. The report of the engineers named above is dated Oct. 30, 1907.

In opening his report Mr. de Varona calls attention to a previous report and estimates on the same subject and by the same engineers, dated Oct. 3, 1906, and reprinted with the present reports. In the earlier report it was shown that filtration of the Croton water supply had been recommended

> by every one of the engineers employed at different times by the city to study and report upon this question in the Water Supply Department, the Aqueduct Commission, the Board of Water Supply and the Finance Department, as well as by those employed by the Merchants' Association, and also . . . . [by] the Commissioner and President of the Department of Health, Dr. Thomas Darlington.

An experimental or testing station was constructed under Mr. de Varona's direction, and in it tests have been carried on since March, 1907. This station was located at the southwest corner of the Jerome Park Reservoir, and was connected with the old Croton Aqueduct by means of a 6-in. pipe. The station included sedimentation basins 10 ft. deep, 71x25 ft. in plan, baffled to form compartments permitting 4 to 60 hours sedimentation; also, two filter beds about 15x30 ft. each, filled with 26 ins. of sand and 16 ins. of gravel. The sand had an effective size of .21-mm. and a uniformity coefficient of 2.62. Drainage tiles were placed below the gravel. Complete apparatus for recording the operations of the plant and for feeding the water with coagulants were provided, and also a complete chemical and bacterial laboratory.

In addition to the experimental plant described, an ozone plant was installed by and at the expense of the United Water Improvement Co., of Philadelphia. This plant was operated under the direction and supervision of the engineers for the city from May 7 to 31, 1906, but it had been previously operated by its owners to make sure that it was in proper shape.

Inasmuch as the results obtained by the ozone plant were not considered satisfactory from the cost viewpoint, what we have to say further regarding it may best be presented here. The plant consisted of a Hungerford mechanical filter for the removal of turbidity; a refrigerator to remove moisture from the air used for producing ozone; an ozonizer of the "H. Blanken System," in which an alternating current of 10,000 volts, 60-cycle, is used; an air and ozone pressure tank, and a 38-ft stack, 22 ins. in diameter, in which the water is subjected to the effect of the ozone. The water is pumped to the top of the stack and the air and ozone are admitted at the bottom through a strainer or spreader. At the

bottom of the stack the water flows into and through a vertical pipe which extends nearly to the top of the stack. The company claims that whereas the usual production of ozone by other methods had not exceeded 16 grams per KW.-hr., with their new ozonizer they could readily obtain 85 grams of ozone per KW.-hr., thus bringing the cost of the process within practical limits. They also claimed that the system of a silent electrical discharge in their ozonizers absolutely secured continuity of action and reliability of operation.

The results actually obtained with the ozone plant, as summarized in Mr. de Varona's report, are as follows:

The experiments showed that of the amount of KW. energy used, about one-quarter was consumed by the refrigerating machine, one-quarter by the transformer and ozonizer and one-half by the compressor. It appeared that the color might be reduced from about 15 to about 5, and bacteria from about 100 to about 7, by the use of about 3,500 grams of ozone per 1,000,000 gals., with an expenditure of about 800 KW.-hr. electrical energy—200 of which were expended on the ozonizer and transformer. With electrical energy costing 2¼ cts. per KW.-hr. (a low price) it appeared that under the conditions of the experiments the process was costing about $20 per 1,000,000 gals., of which perhaps $5 represented the cost of ozone and the other $15 were chargeable to drying the air and pumping it into the water.

Lastly, during the whole time that the plant was in operation, it did not run one single day without stopping, a fact of itself sufficient to demonstrate the impracticability of using the proposed method of ozone purification as an adjunct of our filtration plant, regardless of its cost.

The detailed results of the operation of the experimental water purification plant are not given in the report, and even the summary is brief. Forty-five runs of the filters were made under different conditions, the latter including various preliminary treatments of the water with and without coagulation. It was concluded that after sedimentation, supplemented by coagulation when the water is very muddy or highly colored, a filtration rate of 10,000,000 gals. per acre per day would be "thoroughly safe and feasible." With rates ranging all the way from 3,000,000 to 10,000,000 gals. per acre daily, there was no measurable difference in the bacterial, chemical or physical quality of the effluent or any substantial difference in the volume of water filtered between cleanings, due to the rate of filtration. The initial loss of head increased in direct proportion to the rate of filtration, and with a 10,000,000-gal. rate approximated about 1 ft. with a medium fine sand.

It so happened that during the period covered by the investigations the water was of such a character that "sedimentation did not ordinarily prove to be of assistance," particularly as "the bulk of the suspended matter in the water was due to algae growths, and these did not subside to any very great extent." It is believed that at times sedimentation will be highly advantageous and that during a part of each year a coagulant will be needed to aid the process and to reduce color. It was found that lime and sulphate of iron would not be practicable as a coagulant on account of the expense of the large quantities required for this water. Sulphate of alumina, the report states, at an average rate of 1 gr. per gal., would decidedly improve the filtered water during about eight months of the average year. The average cost of this coagulant would be about $1.10 per 1,000,000 gals., and for its most effective use a sedimentation basin "holding at least 17 hrs'. flow" would be required. After such a period of sedimentation there would still be some of the coagulant in the water that would pass on to the surface of the filters.

Experiments with two different methods of cleaning the filters showed that either would be practicable. One of these was the so-called Brooklyn method employed at the [illegible]pstead and Forest Stream filter beds of the [illegible]rooklyn water-works under the direction of Mr. de Varona (see Eng. News, Aug. 23, 190[illegible]. In this method the water is drawn off down [illegible] within 1 in. of the surface of the filters and [illegible] water is made to flow across the surface [illegible]he bed in temporary channels formed by boa[illegible] set on edge, the top layer of sand being [illegible]ed by hand rakes meanwhile. The operation is continued until the water runs clear, when filtration is resumed. In the other method Blaisdell machine is used to wash the sand [illegible] place without drawing off the water above. [illegible]e apparatus consists of a power-driven [illegible]chine, which moves from one end of the bed to [illegible] other and is provided with hollow revolving rakes placed in an inverted box. Water is forced through the rake teeth into the sand to any desired depth. The rakes are revolved and the dirty water is pumped from the enclosed box. The tests showed that either of these two methods would be less expensive than removing, washing and replacing the dirty sand layer. The proposed filters for New York City have been so designed that either method may be employed.

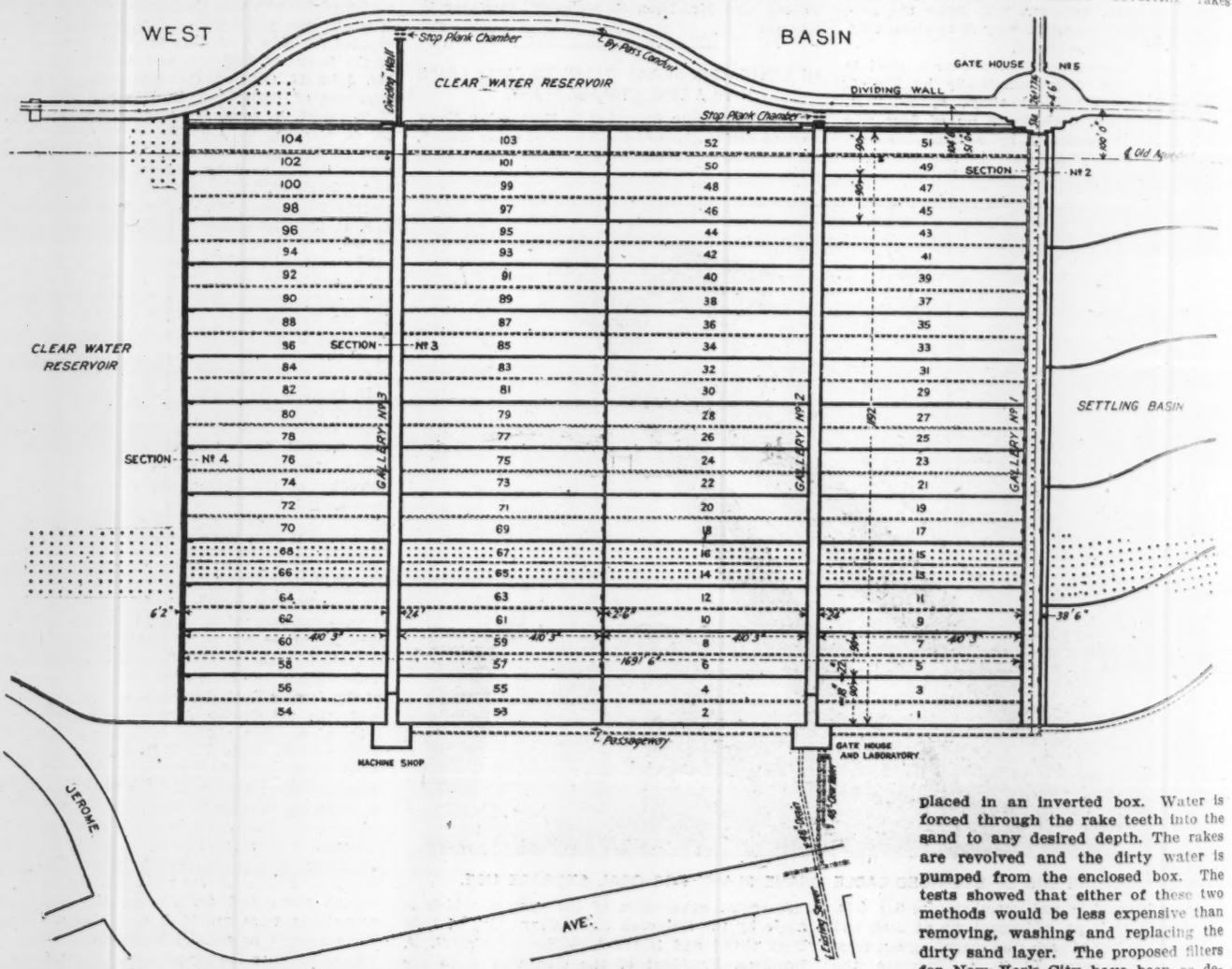


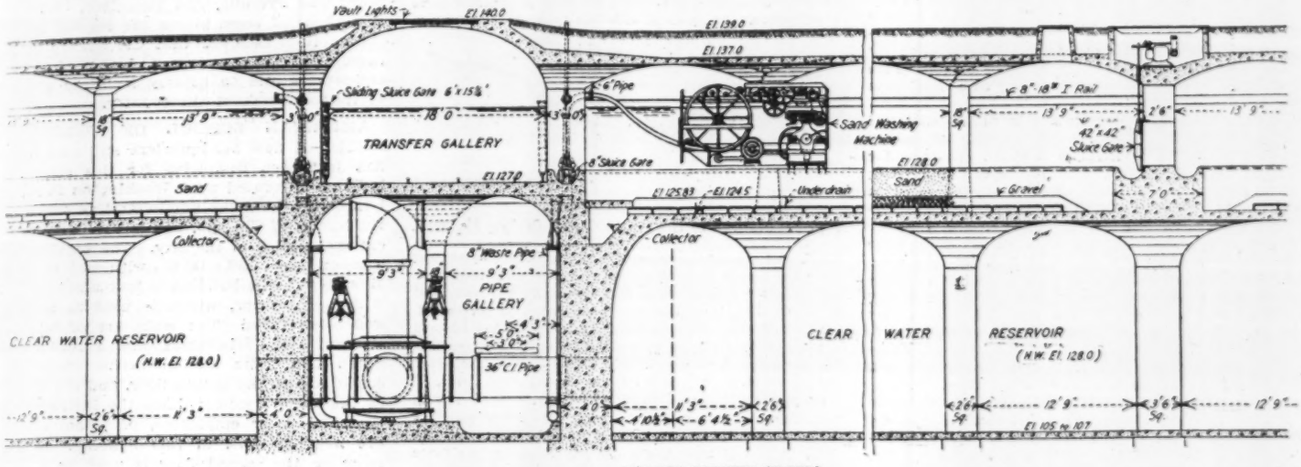
FIG. 1. GENERAL PLAN OF FILTERS PROPOSED FOR CROTON WATER SUPPLY, NEW YORK CITY.
(To be Placed on Roof of Portion of Clear Water Basin.)

The engineers still hold to the belief that the best site for a filter plant to treat the Croton supply is the area designed to form the eastern section of the Jerome Park Reservoir. This embraces 135 acres and the site had been excavated to approximate grade before the work of constructing the second division of the reservoir was suspended, two years ago, on account of recommendations then made by the Aqueduct Commission that the area be used for a filter plant instead of for storage.

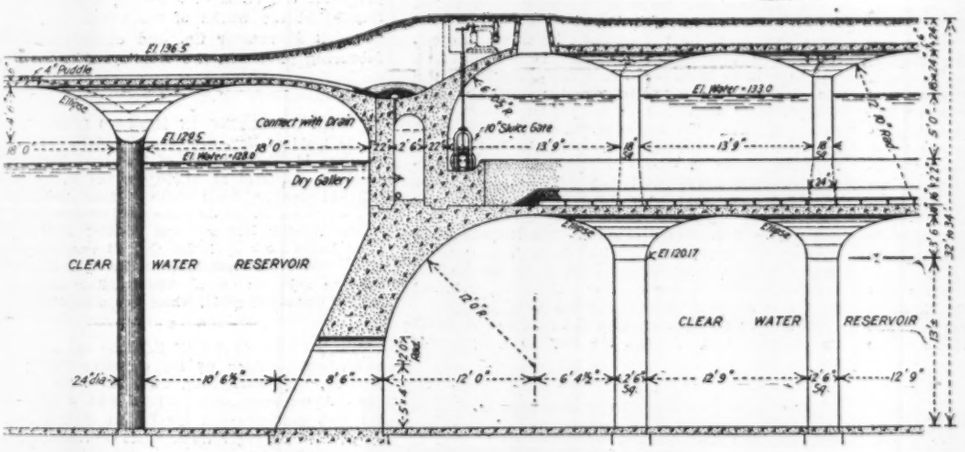
As has already been stated, a 400,000,000-gal. slow sand filtration plant is proposed. This equals the nominal capacity of the old and new Croton aqueducts and is about 85,000,000 gals. in excess of the present average daily consumption. It would be feasible to deliver the whole Croton yield through the new aqueduct and thus to make available the full capacity of the old

aqueduct for the delivery of a temporary supply from the Catskills before the final completion of the aqueduct therefrom now under construction.

The plans submitted provide for a settling basin with a capacity equal to about 18 hrs. flow through the filters, and for a clear-water reservoir with a capacity of 575,000,000 gals. Both the settling and clear-water basins would be covered. The filters would rest upon the roof of a portion of the clear-water reservoir and would also be covered. The basins and filters would be constructed of concrete. (See Figs. 1 and 2).



GALLERY BETWEEN FILTERS.



SOUTH END OF FILTERS.

FIG. 2. SECTIONS OF FILTERS PROPOSED FOR CROTON WATER SUPPLY, NEW YORK CITY.

The settling basin would be divided into five compartments, through which the water would flow at a velocity of only 10 to 20 ins. per min. At one end of the basin the water would pass over a weir into a distributing conduit 1,200 ft. long, extending across one end of the entire filtering area. Mechanically-operated sluice gates would admit the water from this conduit directly onto the filter sand, thus doing away with raw-water piping and flooding the entire 42 acres so that it would "present the appearance of a large pond." Each filter bed would have an area of 0.4-acre and would be divided into three bays, each 410 ft. in length. There would be 25 ins. of filter sand supported by 9 ins. of graded gravel resting on tile underdrains leading to a pipe gallery from which the filtration rate controllers would be placed. Above this pipe gallery would be a transfer gallery in which the washing apparatus would be floated along for admission to the several filter beds.

A chemical and bacterial laboratory are proposed, and also a machine shop for repairs to the mechanical equipment of the plant.

The estimated cost of the filtering plant, settling and clear-water basins, and accessories, as computed from detail drawings, is $7,600,000, the same as was submitted by Mr. de Varona a year ago. To this sum 12% has been added for contingencies, raising the total cost to $8,500,000. The cost of maintenance is estimated at $2.50 per 1,000,000 gals., "including expenses of operation, administration, laboratory, care of grounds, lighting, repair gangs and depreciation, but exclusive of interest and sinking fund charges."

It is believed that if the Board of Estimate and Apportionment would approve the plans immediately, so that bids could be asked and contracts awarded from time to time during the first half of 1908, the whole plant could be in operation by December, 1909. An appropriation of $4,000,000, to be made available early next year, is requested.

LIFTING A 360-FT. DRAWBRIDGE WITHOUT TOOLS was accomplished under the pressure of necessity in a very ingenious manner some years ago. A recent report of how a battleship turret was made to lift itself by its own turning power has resurrected the story. About fourteen years ago a draw span 360 ft. long crossing the Ouachita River on the Houston, Central Arkansas & Northern Railroad, near Columbia, La., built on a pile and concrete foundation, settled on one side, throwing it out of line. Mr. Geo. H. Pegram was Chief Engineer of the railway company. Mr. E. F. Terry, now president of the Terry & Tench Co., of New York City, was sent down to correct the trouble. The bridge was in a jungle hundreds of miles from a city and Mr. Terry had absolutely no tools. Some old stove pipe iron found on the site of the old construction camp was placed under the track, one piece at a time, and the drawbridge was then turned backwards and forwards, being raised by the thickness of one piece of the sheet-metal at each operation. After bringing the bridge up to proper grade, he raised the different track segments to the proper level, and then tamped a rust joint under each segment. This was done with four men to assist him in about a week's time.

EARTH SLIDES ON RAILWAY WORK.*

By H. ROHWER,† M. Am. Soc. C. E.

We know that slides are formed when masses become disconnected, and hang on a slope steeper than the plane of friction due to the character of the material and its ability to resistance. Water being one of the most influential elements in reducing this resistance to a minimum, it is well to provide for proper drainage before slides set in. The golden rule is to "keep the water away from the roadbed." The study of geology is frequently overlooked by the engineer having charge of location, and he gives but little attention to the possibility of encountering slides caused by either the grade or location of line. If drainage is of so much importance, and we know that it is, why not place the line, circumstances permitting, where drainage can be rendered most effective, allow the sun and wind to act upon the roadbed, and pay close attention to the manner of constructing it? And here the writer desires to emphasize as important the selection of the material to be employed in making fills. (In this connection note an article on "The Construction and Maintenance of Railway Embankments," in Engineering News, Oct 9, 1902.—Ed.)

When delegated to investigate the cause of slides in an embankment of one of the main trunk lines in the Middle West, constructed about the year 1861, the writer found the slopes considerably deranged. The embankment, about ¼-mile long and over 22 ft. high in the middle, was continually settling, and notwithstanding the attention given it by the operating department, this evil continued to exist. Trackmen, when called upon to remedy similar breaks, usually apply stone, which on account of the greater weight, increase rather than diminish the evil, and the cause of the slide is thereby not removed. The method employed not being effective, piles were driven and a bridge constructed along and over the fill for such distance as was deemed necessary. As the piles did not rest in original ground, they swayed to and fro, and the maintenance of the line and grade became a matter of great annoyance and cost. About the time this pile bridge required renewal, the writer was asked to make an investigation of the trouble and to recommend what should be done to improve the safety of the road, and, if possible, prevent the slides and dispense with the trestle.

In digging a trench on each side of the track along the foot of the slope and parallel with the track, considerable seepage from the bank poured forth, leading to the belief that the water was retained in the bank by some cause, and was seeking an outlet. The writer then had intercepting drains constructed, extending towards the center of the embankment at intervals of 25 to 50 ft., according to the amount of water apparently confined in the embankment. The drains were then filled with stone—the heavier at bottom and the lighter on top—covered with cinders. This method accomplished the object

*Abstract of a paper in Bulletin No. 90 (August, 1907) of the American Railway Engineering and Maintenance of Way Association, 962 Monadnock Block, Chicago.

†Consulting Engineer, St. Louis, Mo.; late Chief Engineer of the Missouri Pacific Ry.

of draining the embankment and rendered it stable so that the trestle could be removed, and no further difficulty at that point has been experienced.

In prosecuting this work, drills were extended into the center of the embankment, and it was discovered that a number of partly decayed logs were embedded therein. Upon inquiry it was ascertained that the contractor at the time of construction had logs hauled in at night, and one of the farmers, residing in the vicinity, informed the writer that he had been one of those employed to perform that work. The earth on the outside covering up this deception, the water was retained in the inside of the embankment, softening the material dropping into it, and with the heavier material on top, was forced to the sides, thus creating slips or slides. In this case, the slide sounded a timely warning, so that the proper remedy could be employed. However, crevices formed under the roadbed are much more dangerous, producing slides without giving notice. This is often the case where the roadbed rests on the debris hanging on the side of bluffs, especially when bordering on a treacherous stream like the Missouri River.

Water coming down ravines can be readily conducted across the roadbed by bridges or culverts, but in such cases care must be exercised as to outlet. Water falling on the sidehill between ravines or creeks and dropping from bluffs into the debris where it cannot readily be intercepted, will enter the roadbed, penetrate the underlying loose strata and find its way over and along the harder strata, thus creating earth slides. This water keeps the ground under the track in a constant moist state, a menace to the safe operation of the road. Oftentimes it will form crevices, and when once formed they will increase and may reach to the very surface, only to be discovered after a wreck has occurred, and are then usually termed "a washout." Again, the water may soften the material until it becomes slushy and will produce a slip at the foot of the lower slope. Borings made by the writer over a distance of seven miles on parts of track so situated developed the fact that the roadbed developing such defects was invariably located directly against a bluff or perhaps resting on material underlaid by slanting rock. This rock forming a part of the bluff, had been eroded by the action of the water, either river or surface, or both combined.

If the water is collected at frequent intervals and conducted across the track either by means of small boxes (if pipe cannot be utilized) or conveyed in open ditches plastered with cement or rammed with small stone so as to prevent the water from penetrating into the roadway, the danger referred to can be greatly diminished. Drainage is the most essential factor in creating and maintaining a good roadbed; and none is more neglected. After we have discovered the effect and are forced to face the consequences of a badly drained roadway, we form conclusions, only to abandon them again as soon as dry weather sets in, for the temptation to make a good financial showing is often too strong to be overcome.

With relation to slides occurring in cuts during construction and later, the treatise given by Mr. E. E. R. Tratman in Bulletin 88 is so elaborate and circumstantial that little can be added.* Oftentimes slides of this nature are caused by surface ditches, giving the water an opportunity to enter the ground instead of draining it off to the sides. After the water once enters the slopes, it is very difficult to drain them, and every rain will have a tendency to increase the difficulty. At the west entrance to the Oregon Short Line tunnel in Idaho, where the sides broke off vertically and heaved the track at times to such an extent as to seriously interrupt and delay the handling of material from the tunnel, the writer applied with good results ordinary horizontal bracing, in the manner shown in Fig. 1.

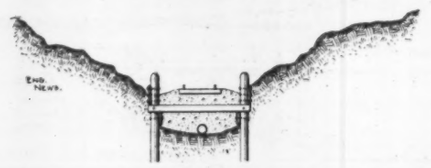


Fig. 1. Method of Bracing a Cut in Sliding Material.

The most remarkable slide coming to the notice of the writer was encountered on the White River Ry., at the entrance of a tunnel 2,650 ft. long (Tunnel No. 3, at Omaha Drive, Ark.), its magnitude precluding all thought of removing it. The disturbance first manifested itself at what might be termed a sidehill cut. In removing the footing, the mass of clay seemed to lose its hold on the rock whereon it rested. It began breaking off, first showing cracks insignificant in size and their location being confined to the right-of-way, but later reaching far out into the adjoining hills, bringing down trees and forming breaks in the surface 15 to 25 ft. in height and perpendicular in appearance. The tunnel penetrates a sag in the Ozark mountains, consisting of a so-called boulder formation, lime and rock being found intermixed with clay, a hydrated silica of alumina of brownish color, due to the presence of iron oxide. This clay is very plastic, especially in the approaches, where action of water is not constant as in a tunnel. Here the layer of clay was from 5 to 100 ft. thick, underlaid with strata of solid rock of smooth surface and slanting at an angle of from 5 to 10° toward the creek along which the lien had been located, then in course of construction. The grade of the roadbed entered the rock 20 ft. below the surface; in other words, the approach to the tunnel had a 20-ft. rock cut with clay in the slope overlying it.

As soon as cracks appeared on the surface, extra precautions were taken against surface water. The surface ditches were given steeper grades, and, where possible, the bottoms were cemented so that the water could drain off more quickly, thus reducing chances of penetration to a minimum. In spite of this the ground continued to break and started to move toward the open cut, at first dropping into it little at a time. It gradually increased, until after a rather heavy rain the entire cut was filled with this stuff, involving an expenditure of $1 per cu. yd. for its removal. Though the moving masses had adopted a slope of nearly 1 on 2, the breaks continued, stretching for more than 150 ft. into the hill above the grade of the roadbed, and over 500 ft. distant from same.

To prevent similar occurrences after the road was in operation, the writer had the rock cut arched over for a distance of 600 ft. from the portal of the tunnel. An arch, framed of timber, without protection against "side pressure," cannot be relied upon as a permanent safeguard against slides. To make it serve, however, should the mass continue to move, the clay bank was removed for a distance of 12 ft. from the edge of the rock cut, and holes were drilled into the rock 8 to 10 ft. in depth, and from 10 to 15 ft. apart, in a row along the foot of the clay slope, shots being placed therein and fired simultaneously by means of an electric battery. The rock was broken but not scattered, a trenchlike crack appearing at the surface. The writer then had logs cut from the timber, of which an abundance was found in the immediate neighborhood, and these logs were placed alongside each other with the butt end in the rock crevices, the other end overhanging the timber arch, and resting upon its top (Fig. 2). The material under the logs and between the logs and the arch was tamped, thus forming a solid flooring over which the material could slide, distributing it over the entire arch and serving as a weight instead of a thrust.

The further object of cracking the rock was to permit the water coming through the clay to escape, thus leaving the footing dry and in better position to act as a support. The plan worked very satisfactorily. The first rain produced another slide, the logs carrying the material over the arch. With the drain in the rock at a distance of 12 ft. from the edge of the cut and over 30 ft. from the foot of the new slope, a good foothold had been created which served the purpose, for no further movement of the overhanging masses (estimated by the engineer in charge as reaching the enormous quantity of 130,000 cu. yds.) has taken place since that time (1904). The few sticks of timber in the arch which had moved, were displaced not more than an inch.

This experience led the writer to the conclusion that many similar slides formed by masses moving along a rock surface might be checked by boring holes down to rock, lowering dynamite and breaking the surface by means of blasts, and actual practice has confirmed this view.*

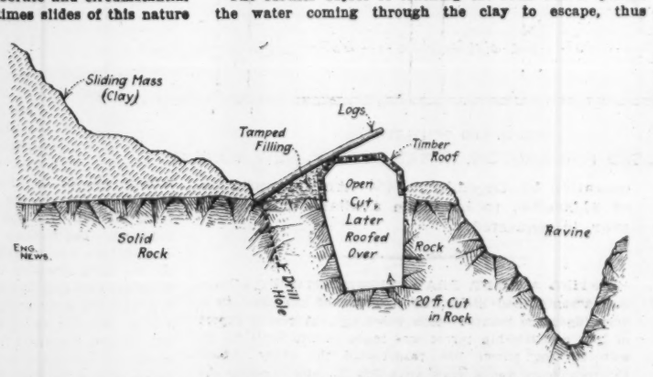


FIG. 2. ROOFED CUT IN ROCK OVERLAID BY SLIDING CLAY.

*Engineering News, Sept. 13, 1906.

NOTES FROM ENGINEERING SCHOOLS.

UNITED STATES MILITARY ACADEMY.—According to current press reports a new method is planned for conducting the physical examinations of the nominees for cadetship. It is proposed to have only five army posts where these examinations will be made. These are: Fort Slocum, New York; Columbus Barracks, Ohio; Jefferson Barracks, Missouri; Fort Logan, Colorado; The Presidio, San Francisco, Cal. As the first three of these places are regular recruiting points, it is believed that the officers stationed there will be in a position to best conduct the examinations and to greatly facilitate uniformity of tests throughout the country.

AMERICAN SCHOOL OF CORRESPONDENCE.—A new headquarters and office building has just been completed for this school. The building is located near Washington Park, about two blocks from the administrative offices of the University of Chicago, and is thus near the educational center of the city. The building covers a ground area 136 × 96 ft., with an interior court 40 × 50 ft. The building is four stories in height with a basement, which is used as a shipping and stock room. The walls are of brick, with Bedford stone trimmings, and a roof of moss-green tile. The administrative offices of the school are on the second floor, and the remainder of the space accommodates the instructors, editors and other employees, of whom about 300 are now at work in this building. A lecture room on the second floor is used as a meeting place for the clubs of students which have been formed at the works of the Crane Co., the McCormick Harvester Co. and other large manufacturing plants in the vicinity of Chicago.

A FIRE RESULTING IN $2,267,500 LOSSES occurred on the night of Nov. 8 at Superior, Wis. The greatest loss was in Elevator "A" of the Great Northern Ry., which is estimated at $1,250,000; the Grand Republic mill and elevator, Great Northern flour sheds, Freeman mill and elevator, Mankato mill and elevator, the plants of the Webster Mfg. Co. and Whitney Bros., and the Great Lakes Dock & Dredge Co., all were heavily damaged. The fire started in Great Northern elevator "A" from an unknown cause. The building contained over 600,000 bushels of grain, which was a total loss.

SEVEN PERSONS WERE KILLED and 20 injured in a head-end collision on the Canadian Pacific Ry. on Nov. 14, near Moor Lake, Ont., 100 miles from North Bay. A passenger train collided with a light engine, and both engineers and one fireman were killed. The cars of the passenger train, which was derailed, turned turtle and burned.

Six men were killed and five seriously injured in South Milwaukee on Nov. 13, when a south-bound train on the Chicago & Northwestern Ry. plowed into a crowd of people who, ignoring lowered gates, attempted to cross the tracks. The train was not derailed; it was said to be running at nearly 60 miles per hour.

At Marysville, Cal., on Nov. 13, a Northern Electric local car collided with the engine of a freight train at a grade crossing. One person was killed and 20 injured—one fatally.

AN EXPLOSION OF NITRO-GLYCERINE at the plant of the Dupont Powder Co. at Bradner, Ohio, on Nov. 13, killed two men, seriously injured another, and wrecked the plant. Nitro-glycerine in cans was being loaded on to a wagon when one of the men dropped a can; he, the wagon, and three horses were blown to fragments by the resulting explosion. The dropped can exploded first, then the magazine, then the factory.

Two tons of powder, ignited by an electric spark, exploded on Nov. 15, at the plant of the Pittsburg Fulminite Co. at Zellienople, Pa. One man was killed. The estimated damage is $10,000.

A natural gas explosion occurred on Nov. 15, in a dwelling house in Pittsburg. Twenty-five persons were injured, two fatally; and the house was demolished.

Six men were killed by a boiler explosion on Nov. 12, in the gin-house of a plantation near Pine Bluff, Ark.

*A case of this kind in connection with improvements on the Cleveland, Cincinnati, Chicago & St. Louis Ry. was noted in our issue of May 16, 1907.—Ed.

RAIL IMPACT TESTS have been carried on by the Pennsylvania R. R. during the past few weeks on a specially arranged stretch of track of the West Jersey and Sea Shore R. R., near Clayton, N. J. The object of these tests has been to determine the nature and extent of the difference in the action of steam and electric locomotives, on the rails because of the lower center of gravity of the latter. It is stated that this special track section of 166 ft. is provided with cast-steel ties to which the rail is attached by a block which allows a definite movement of the rail as the engine passes. Through this movement it seems that the impact may be determined for different locomotives at different speeds over straight or curved track. These tests involving high speed runs of both steam and electric locomotives have been reported in the daily press as novel and startling races between these two types.

A SPEED OF 34¼ KNOTS PER HOUR, or nearly 40 land miles per hour, was maintained for 6 hours on Nov. 15, by the British destroyer "Mohawk," according to press despatches. The trials took place in the North Sea, off the Isle of Wight.

A QUICK INSTALLATION OF STEAM TURBINE units was recently made at the South Chicago works of the Illinois Steel Co. The contract with the manufacturers, the Allis-Chalmers Co., was signed May 13, 1907; shipment was commenced from the factory May 25, and the erection of the two units contracted for was completed on July 16, and the machines were put into commercial service July 22. They are reported to have been since then in almost continuous operation, carrying up to 50% overload. The machines are in a temporary wooden building with none of the usual facilities for erection. Each unit consists of an Allis-Chalmers turbine coupled to a 1,000-KW. 25-cycle, 3-phase, 2,300-volt generator, with a direct connected exciter.

IRON SMOKESTACKS have been replaced by concrete in a novel manner at the plant of the Canadian Portland Cement Co. at Marlbank, Ontario. At this plant four stacks each 60 ft. high and 14 ft. in diameter, lined inside with one thickness of fire brick, recently showed signs of corrosion in the plates. Instead of replacing with iron or steel it was decided to coat the outside of each stack with a 4-in. layer of concrete. For this purpose a plate iron cylinder, 56 ins. in diameter and 48 ins. high was used as a form and moved up the stack as the concrete, which was deposited within it, had set. Circumferential reinforcement of No. 7 wire was placed every vertical six inches in the middle of the 4-in. thickness. It is estimated that about $1,200 was saved in the construction by concrete covering above the cost of new iron or steel stacks.

AUTOMATIC SPRINKLERS HAVE BEEN INSTALLED on the steamer "Plymouth," of the New England Navigation Co., which was practically destroyed by fire about 18 months ago, only the steel hull and portions of the engines having been saved. As she stands now, the "Plymouth" is practically a new boat, having been in commission about two months. She was built for freight and passenger service on Long Island Sound, is 376 ft. long, of 3,770 gross tons register, and is permitted to carry 1,500 passengers.

With the exception of the steel hull and bulkheads, of which there are five, the boat is constructed largely of wood, very little metal being used above the main deck. In rebuilding the boat, careful attention was given to the matter of fire protection. Above the main deck an attempt has been made to divide the boat into three fire sections by means of sheet-iron-sheathed wooden partitions 1½ ins. in thickness. Doorways in these partitions are closed by metal-covered sliding wooden doors. The usual equipment of fire hose, extinguishers, etc., is provided, with the addition of the sprinkler system mentioned.

The sprinkler system covers the whole vessel with the exception of the engine-room and fire-room. It was installed early in 1907 by the General Fire Extinguisher Co., and employs 1135 Grinnell sprinkler heads. The primary source of water supply is a Blake pump with a capacity of 1,000 gals. per min., drawing in salt water through an 8-in. pipe extending directly through the hull of the vessel. It discharges through one 6-in. pipe into two headers, from which 20 4-in. leads supply the various portions of the vessel. The pump is equipped with a regulator, and water pressure is maintained at 80 lbs.

The officers of the vessel report that the system has given perfect satisfaction since the vessel was put into commission. A few cases have been reported of sprinklers being bent on the freight decks, but no leak has been reported. The system is not wholly automatic, as it requires some degree of human intervention. At the occurrence of a fire a thermostat gives an alarm at an annunciator in the engine-room, showing on which section of the sprinkler system the fire has occurred. The engineer at once opens the corresponding valve, which puts that section of the sprinkler system under full pump pressure.

Engineering News has long maintained that the construction and the fire-preventive equipment of passenger-carrying vessels on our inland waters has been inadequate from the standpoint of public safety. Numbers of disastrous steamboat fires—notably that of the "General Slocum"—bear witness to this. It may be of interest to note, in connection with the subject matter of the foregoing description, a letter which was published on page 73 of Engineering News for July 21, 1904 (shortly after the "Slocum" disaster), suggesting the installation on vessels of automatic sprinkler systems.

AN AMPHIBIOUS AUTOMOBILE was successfully tried on Nov. 13, on upper Riverside Drive, New York City, at Fort Washington Point on the Hudson River. The machine—or craft, as you please—resembles a narrow yawl, decked over fore and aft with the exception of a cockpit for the pilot and a space for two passengers. It is 30 ft. long, 6 ft. beam, and about 3 ft. 6 ins. deep amidships; when afloat it draws about 22 ins. of water. A De Dion 2-cylinder, 20-HP. gasoline engine furnishes the power, which may be applied to propeller or wheels at will. The wheels are of wood, plated with thin steel, and have hard rubber tires. The machine is the invention of Jules Reveilliers, of Paris. In its trials it showed good speed in the water, and good hill-climbing ability on land.

PERSONALS.

Mr. Robert Sherman, Superintendent of the Los Angeles Pacific Ry., has resigned.

Mr. Francis W. Byrne has resigned as Superintendent of the H. C. Frick Coke Co., at Footedale, Pa.

Mr. J. F. Coleman, Chief Engineer of the New Orleans Great Northern R. R., has tendered his resignation to take effect Jan. 1.

Dr. Edmund H. Stevens has resigned from the Water Board of Cambridge, Mass. Dr. A. W. Dudley has been appointed as his successor.

Mr. William Parker, Division Engineer at Boston of the Boston & Albany division of the New York Central & Hudson River R. R. Co., has been made Principal Assistant Engineer.

Mr. A. Bickel has resigned as Sales Manager of the Hodge Electric & Mfg. Co., and is now Contract Manager with the Freeborn Engineering & Construction Co., of Kansas City, Mo.

Mr. E. P. McKinney, Superintendent of Motive Power of the New Orleans Ry. & Light Co., was recently appointed Superintendent of Equipment, in addition to his other duties.

Mr. Paul Bernard, Roadmaster of the Chicago, Cincinnati & Louisville R. R., at Richmond, Ind. has been appointed Superintendent of Maintenance of Way, with headquarters at Chicago.

Mr. Howard E. Smith, M. Am. Soc. C. E., has been appointed Resident Engineer by Frederick Skene, New York State Engineer and Surveyor, and has been assigned to work at Oswego, N. Y.

Mr. William Anderson, formerly Superintendent of the Cascade Water Power & Light Co., has been appointed Hydraulic Engineer of the West Kootenay Power & Light Co., at Rossland, B. C.

Mr. W. E. Harrington, M. Am. Inst. E. E., President of the Pottsville Union Traction Co., has resigned, the vacancy being filled by the election of Mr. P. G. Gossler, of New York City, M. Am. Inst. E. E.

Mr. Theodore Stebbins, M. Am. Inst. E. E., has been appointed General Manager of the Texas Traction Co., which will shortly begin the operation of the interurban electric road between Dallas and Sherman.

Mr. B. E. Merwin, General Superintendent of the Interurban Ry. & Terminal Co., of Cincinnati, has resigned to accept a corresponding position with the Aurora, Elgin & Chicago Ry. Co., with offices in Chicago.

Mr. S. A. Mackey has been appointed Supervisor of the Cleveland, Cincinnati, Chicago & St. Louis Ry., with offices at Bellefontaine, Ohio. The position was made vacant by the resignation of Mr. Elmer Allebaugh.

Mr. Chas. A. Moffatt, Chief Engineer of the Blast Furnace Department of the Republic Iron & Steel Co., has resigned to accept the position of Superintendent of Machinery for the Birmingham (Ala.) Coal & Iron Co.

Messrs. A. D. Knight and W. C. Steele, Street Superintendent and City Engineer respectively of Ocean Park, Cal., have resigned; the former to manage an orange grove, the latter to take up private engineering practice.

Mr. E. H. Coapman, General Superintendent of the Southern Ry., at Danville, Va., has been appointed to the position of Manager of the Northern and Eastern districts of the road, to succeed the late Mr. J. N. Seale, whose death we announced last week.

Mr. Warren R. Clifton has resigned as General Superintendent of the Carnegie Blast Furnaces at Sharon, Pa., and will take the position of Superintendent of the new furnaces of the Jones & Laughlin Steel Co., at Aliquippa, Pa.

Mr. Edward C. Clay, Heating Engineer of the Walworth Mfg. Co., of Boston, was presented on Nov. 15 with a silver loving-cup, by the employees of the company, in recognition of the completion of 60 years of uninterrupted service.

Mr. E. W. Moore has resigned from the managership of the Galena Iron Works Co., at Platteville, Wis., and will join the Ingersoll-Rand Co. as manager of their department which manufactures the Temple-Ingersoll electric air drill.

Mr. Geo. G. Crawford, formerly of the National Tube Co., has been elected President of the Tennessee Coal, Iron & R. R. Co. Mr. J. A. Topping, who has been Chairman of the Board of Directors, has resigned and the office has been abolished.

Rear-Admiral Asa Walker, U. S. N., who has been Superintendent of the Naval Observatory at Washington for nearly two years, was retired on Nov. 13. Commander Winterhalter, who has been on detail at the Observatory, will temporarily act as superintendent.

Mr. W. E. Reed, M. Am. Inst. E. E., has opened offices for general consulting work in the Machesney Building, Pittsburg. Mr. Reed has been associated with the Westinghouse interests since 1891, when he entered the employ of the Westinghouse Electric & Mfg. Co. as an engineering apprentice.

Mr. M. M. Dooley has been appointed Master Mechanic of the Alabama Great Southern R. R., at Birmingham, succeeding Mr. J. W. Evans. Mr. Evans has been appointed Superintendent at Birmingham, filling the vacancy left by the resignation of Mr. R. E. Boswell, noted here last week.

Prof. Loyal W. Trumbull, of the Department of Mining and Geology at the University of Wyoming, Laramie, has resigned to accept the position of General Superintendent of the Telegraph Drift Mining Co., of Downieville, Cal., and Chicago. He will also do consulting work for general clients.

Mr. Frederick G. Myhlertz has tendered his resignation as Engineer of Construction, Bureau of Building Inspection, Philadelphia, to take effect on Dec. 1. He will associate himself with Scott, Mitchell & Co., of Philadelphia, bankers and fiscal agents of the Seaboard Portland Cement Co., who are building a plant at Catskill, N. Y.

Prof. Robert Sibley, Head of the Departments of Mechanical and Electrical Engineering at the University of Montana, has resigned to take up consulting work in electrical and hydraulic engineering, with offices in Missoula. He will be succeeded at the University by Mr. M. P. Craighill, formerly associated with the Mechanical Appliance Co., of Milwaukee.

Obituary.

Tod Ford, President of the Youngstown Steel Co., of Youngstown, Ohio, died at Pasadena, Cal., on Nov. 4. He was born in Cleveland in 1854.

Aaron R. Thompson, formerly Canal Superintendent and Commissioner of Public Works at Syracuse, N. Y., died at Syracuse on Nov. 14, at the age of 58.

H. W. Scott, Principal Assistant City Engineer of Seattle, died on Nov. 1 at Wanatchee, Wash. He was 47 years of age. His first important piece of work after entering the employ of the city was the construction of the Cedar River water system. After the completion of that project he was appointed to his late position, with general supervision of all city engineering work. During the last three years he has been in charge of the construction of all water-system extensions. Mr. Scott was a member of the Pacific Northwest Society of Civil Engineers, and was Treasurer from its founding until a year ago.

C. D. Wyman, of the firm of Stone & Webster, of Boston, died on Nov. 10 in Montana, while en route from Boston to Seattle. Mr. Wyman was born in Racine, Wis., on Aug. 28, 1850, and for the last 20 years has been well known in street railway work in this country. He was graduated from the University of Chicago in 1872 with the degree of B. A., and his street railway career began in 1874 with his election as Secretary of the Central Park, North & East River R. R. Co., of New York City. Prior to his connection with Stone & Webster, he held the position of General Manager of the New Orleans Traction Co. Mr. Wyman was a member of the Transportation Club, of New York City, and of the Exchange, City and Twentieth Century Clubs, of Boston. In 1889-90 he was First Vice-President of the American Street Railway Association. A widow and three daughters survive him.

Storm Bull, Professor of Steam Engineering at the University of Wisconsin, died on Nov. 18 from cancer of the stomach. Prof. Bull was born at Bergen, Norway, on Oct. 20, 1856, and was graduated from the Fed-

eral Swiss Polytechnic Institute at Zürich with the degree of Mechanical Engineer in 1877. He came to this country, and in 1879 became Instructor in Mechanical Engineering at the University of Wisconsin. In 1884 he was made Assistant Professor, and in 1886 Professor of Mechanical Engineering. He held the last named position until 1890, when he was appointed Professor of Steam Engineering.

Prof. Bull was well-known to readers of Engineering News, through his contributions to our columns, mainly in the Engineering Literature Supplement. He was the author of steam-engineering text-books in wide use. At the Paris Exposition in 1900 he was Vice-President of the Jury of Awards, and at the Louisiana Purchase Exposition in 1904 was Acting President of the Jury of Awards. He had served in the government of the City of Madison, both as an alderman and as mayor, the latter in 1901-02.

Prof. Bull was a member of the American Society of Mechanical Engineers; the Western Society of Engineers, in which he won the Chanute Medal in 1903; the Society for the Promotion of Engineering Education, of which he was Vice-President in 1901-02; and the Western Railway Club. He was a nephew of the famous Norwegian violinist, Ole Bull.

ENGINEERING SOCIETIES.

COMING MEETINGS.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 21-22. Fifteenth general meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL DRAINAGE ASSOCIATION.
Nov. 25-27. Annual convention at Baltimore. Chairman Ex. Com., Col. A. G. Bernard, 1420 New York Ave., Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 3-6. Fifty-fourth annual meeting at New York City. Secy., Calvin W. Rice, 29 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 5-7. Convention at Chicago. Secy., C. R. Richards, Columbia University, New York City.

ASSOCIATION OF TRANSPORTATION AND CAR-ACCOUNTING OFFICERS.
Dec. 10. Annual winter meeting at Chicago. Secy., G. P. Conard, 24 Park Place, New York City.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 20-25. Fourth annual convention at Buffalo. Secy., W. W. Curtis, 585 Caxton Bldg., Chicago. Convention Manager, Dal H. Lewis, 760 Main St., Buffalo.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—It was announced at the meeting held on Nov. 12 that during the coming annual meeting of the society in December an excursion would be made through the Pennsylvania Railroad tunnel, starting from the Hoboken side.

TRI-STATE MINING ASSOCIATION.—A meeting will be held at Dubuque, Iowa, on Friday, Nov. 22. The morning session will be devoted to informal discussion of practical mining subjects. Among papers to be read at the afternoon session are the following: "Legal Questions in Mining," by Francis A. Harper, Chicago; "The State School of Mines," by R. I. Dugdale, Platteville, Wis.; "Relation of Good Roads to Mining," by W. O. Hotchkiss, State Geologist of Wisconsin; and "Economic Geology," by Ellwood C. Perisho, State Geologist of South Dakota.

NATIONAL DRAINAGE CONGRESS.—The program of the coming convention at Baltimore, Nov. 25 to 27, includes, in part, the following addresses and papers: Monday, Nov. 25, morning: Addresses of welcome by Gov. Warfield and Mayor Mahool; response by Mr. Geo. E. Barstow; afternoon, "Salt Marsh Drainage in New Jersey, Direct and Indirect" (illustrated), Prof. John B. Smith, Entomologist, N. J. Agr. Exp. Station; "The Status and Present Need of Agricultural Drainage," C. G. Elliott, Chief of Drainage Investigation Bureau, U. S. Dept. of Agriculture; "Drainage and the Public Health," J. S. Cosgrove, State Drainage Commissioner, South Carolina; and "Reclamation of Wet Lands in Minnesota," Geo. A. Ralph, State Drainage Engineer. Nov. 26: "The Mosquito as a Sanitary Problem," Prof. A. M. Ayres, M. D., New York City; "Relation of Drainage to Mosquito Extermination," Henry Clay Weeks; "Control of Floods by Farm Management," Dr. W. J. McGee; "Drainage Work of the Reclamation Service," F. H. Newell; and "Forests in Their Relation to Drainage," Gifford Pinchot. Nov. 27: "Drainage of the Everglades of Florida," Gov. Broward of Florida; and "Geology of Swamp Land Areas," Dr. George Otis Smith, Director U. S. Geological Survey.

Col. A. G. Bernard, 1420 New York Ave., Washington, is Chairman of the Executive Committee of the Association; Thomas L. Cannon, 1225 Missouri Trust Bldg., St. Louis, is Secretary.

AMERICAN MINING CONGRESS.—The tenth annual session was opened on Nov. 11 at Joplin, Mo. The first day was devoted to an excursion in automobiles to a number of the camps of the Joplin district, about 300 delegates making the trip. At the opening session, at 8 p. m. that evening, Gov. Folk, and Mayor Osborn of Joplin, welcomed the delegates with addresses.

On Nov. 12, after the business of the Congress, Mr. W. R. Ingalls, Chairman (Editor of the "Engineering and Mining Journal"), presented the report of the committee on a uniform law governing metalliferous mining and quarrying in the various states; Dr. Erasmus Haworth, of the State University of Kansas, presented a paper on "Prospecting for Gas and Petroleum"; Dr. E. R. Buckley, of the Missouri School of Mines, presented "Lead and Zinc Mining in the Ozark Region"; Mr. S. Duffield Mitchell, of Carthage, Mo., presented "Tariff on Zinc Ores"; and Dr. J. A. Holmes, of Washington, D. C., "The Waste of the Nation's Mineral Resources." Mr. J. H. Richards, President of the Congress then delivered an address.

Among the papers presented on Nov. 13 were "The Deflocculation of Non-metallic, Amorphous Bodies," by E. G. Acheson, of Niagara Falls, and "How Long Will the Supply of Coal Meet the Increasing Demands of Commerce and Trade," by E. W. Parker, of Washington, D. C.

On Nov. 14 there were presented papers on "Gypsum Rock: Its Use and Manufacture into Calcined Plaster," by C. O. Bartlett, of Cleveland; "The Scope and Present Status of Mining Engineering Education in the United States," by Dr. Victor C. Alderson, President of the Colorado School of Mines. Other papers relative to mining engineering education were presented by Dr. Milnor Roberts, of the Washington School of Mines, Seattle; Prof. Robert H. Richards, Massachusetts Institute of Technology; Lewis Young, Missouri School of Mines; H. H. Stoek, Editor "Mines and Minerals"; and Prof. Robert Peele, Columbia University School of Mines. Dr. Geo. Otis Smith, Director of the U. S. Geological Survey, delivered an address on "The Relations of the U. S. Geological Survey to the Mining Industry"; and Mr. John Hays Hammond spoke on "A Federal Department of Mines and Mining."

Among the addresses on Nov. 15 was one on "Mines and Mining in the Philippines," by Robert S. Oberfelder, of Sidney, Neb. Saturday, Nov. 16, was devoted to excursions to neighboring mining towns, by electric car.

Thirty-six states were represented by delegates, the attendance being nearly 400. Joplin proved an excellent, hoist, according to the Secretary; and the opportunity to visit her mines, both above ground and underground, was eagerly taken by visiting delegates. There was an exceptional exhibit of lead and zinc ores, maintained by mine operators of the Missouri, Kansas, Arkansas and Indian Territory districts, in the Theatorium Annex, Joplin.

NEW YORK RAILROAD CLUB.—The second meeting of the season was held on Friday evening, Nov. 15, with President H. H. Vreeland in the chair. The secretary reported a total number of members to date of 1,416 and the treasurer's report showed a balance of $14,000 on Nov. 1. The report of the election tellers was presented and resulted in the reëlection of the entire staff of officers for another term. After a short address by the president, the paper of the evening was presented by Mr. W. S. Quigley, Mechanical Engineer and Salesman with the Rockwell Engineering Co. of New York City, entitled "The Brass Foundry: Modern Methods of Melting and Handling Metal."

Mr. Quigley's paper concerned in the main the superior economy of the oil furnace for brass melting. In introducing his subject, Mr. Quigley said: "The gray iron, malleable and steel foundry are provided with a chemist, and modern equipment for melting and handling the metal; but seldom so is the brass foundry, which is often located in one corner of the iron foundry (to the disadvantage of both) or crowded in some poorly lighted and ventilated building entirely inadequate." The author pointed out the fact that, in the value of metal melted in a day, the expenditure on the brass foundry was often higher than that on the iron foundry. Apropos of the common lack of uniform system in brass founding, he cited the case of a Cleveland foundry in which one of the Rockwell furnaces had been installed. Being advised by the management that the foundry losses had increased, he gave the case his personal supervision, recommending certain radical changes in the brass-founding practice at that plant. The result of the application of Mr. Quigley's suggestions was a reduction in the number of bad castings, more metal melted, and reduction in the metal shrinkage from 11% to 7%, the total resultant being an actual saving of $33 per day, or about $858 per month. In that foundry the value of the raw material melted each day was over $1,300.

"After the molding machine," said Mr. Quigley, "the modern open-flame oil furnace—by which I mean the tilting and revolving oil furnace in which the metal is melted in direct contact with the flame, without the aid of crucibles—has done more to bring about changes in brass foundry methods than any other device. Melting the non-ferrous metals in the open flame is by no means new. Many large and successful foundries are using, and have used, open-hearth furnaces successfully for large work; but until the convenient revolving [illegible] furnaces were introduced, very little was known of [illegible] method of melting and the crucible was considered [illegible] absolute necessity."

One of the main economies in the use of [illegible] furnaces brought out by Mr. Quigley in his paper was [illegible]e saving in time during the working day. Where [illegible]tomarily crucible-furnace practice meant kindling th[illegible] fires at 5.30 or 6 a. m., having the first heat ready [illegible] pour out about 10 a. m., the second at 1.30 p. m., and [illegible]he third at 3.30 p. m. (three heats only per day), the [illegible] furnace permitted having the first heat ready at 8.30 [illegible]., with successive heats ready to pour at intervals [illegible] from 30 minutes to 1 hour throughout the day—"the [illegible]tal now waiting for the molder, not the molder for the [illegible] metal as before."

Citing from the results of some tests made [illegible] April, 1905, Mr. Quigley gave some figures of consid[illegible]able interest. The oil consumption averaged 1.53 gal[illegible] per 100 lbs. of metal melted; and the result, compared with melting in crucibles in that particular foundry, was as follows: Average metal losses for the oil furna[illegible] 3.18%; average metal losses for the crucible furnace, 3.25%; total cost per ton of metal melted in oil furnace, $3.36; total cost per ton of metal melted in crucible furnace, $5.18.

A large bearing manufacturer furnished Mr. Quigley with the following figures: (1) Cost of melting in crucibles—Bearings and castings shipped May and June, 1905, 646,519 lbs.; deduct weight of lining in bearings, which has not melted in crucibles, 30,000 lbs.; total balance, 616,519 lbs. Cost of coke, $693.85; cost of crucibles, $689.23; total, $1,383.08. Cost of melting, per 1,000 lbs., $2.24. (2) Cost of melting in oil furnace—Metal melted from Aug. 18, 1905, to Jan. 12, 1906, 750,014 lbs.; cost of oil, $683.71; cost of power, $183.16; total, $866.77. Cost of melting, per 1,000 lbs., $1.15. These figures show a saving, in favor of the oil furnace, of $1.09 per 1,000 lbs. of metal melted. They do not include the cost of lining crucibles for the oil furnace.

In discussing the paper, Mr. Geo. R. Henderson raised a question as to the oxidizing of the white metals in the alloy by the application of the open flame, calling attention to the distinct bluish-white tint of the flame within the furnace, characteristic of burning zinc. Mr. Quigley in replying recommended the addition of a small extra quantity of zinc to compensate for this burning out effect, which, he admitted, existed. With proper manipulation, Mr. Quigley stated, the metal losses could be held down parallel with those of ordinary crucible practice. Replying to Mr. Van Ness De Lamater, who asked for comparative figures concerning oil and coke fires, Mr. Quigley stated that practical tests had demonstrated the oil to be equal or superior in economy to coke.

Mr. Chas. M. Robbins raised the question of the use of iron molds for brass founding, to eliminate the necessity for molding machines. The difficulty, Mr. Robbins stated, has been in the brass and similar alloys not casting smoothly in iron molds. He had tried, he stated, painting the interior of iron molds with various preparations without success, and recommended research in this direction.

Mr. Werner Boecklin contributed a written discussion, in which he recommended more extensive installation of overhead transportation systems in and about the brass foundry, and also extending from the foundry to the machine shop, etc. (Mr. Quigley, in his paper, had touched slightly upon this point). Giving some details concerning the proper mode of installation of overhead systems, Mr. Boecklin stated that the plain trolley was better for the brass foundry than power-driven trolleys. He briefly outlined a complete system of overhead track which could be built for $2,500, and which would require for its adequate operation ten chain hoists, costing an additional $500.

Prof. H. Wade Hibbard, of Cornell University, requested information as to the order in which metals are charged into the furnace for melting, concerning which Mr. H. A. Brooks cited a case in which he had tried adding the lead first and "dissolving" the copper in the molten lead, with some saving of fuel; Mr. Brooks stated that microscopic examination of the resultant alloy failed to disclose any structural differences. Mr. William E. Simons, of the Pioneer Cast Steel Co., contended that the intelligence of the operator had as much to do with the quality of the alloy as the quality of materials used and the order in which they were charged.

Prof. Hibbard described an interesting method of obtaining uniform temperatures in melting bearing alloys: A coil of wire was enclosed in a non-fusible tube, and the tube immersed in the molten metal. A current of electricity was then passed through the wire, which was heated until it glowed with the same brightness as the molten metal when the metal was at a temperature which had been previously determined to give good results. The amount of current flowing was measured, and in subsequent heats the metal was raised to a temperature at which it had the same brightness as did the wire carrying the same amount of current which it had previously carried.